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## Classification of Electric Furnaces.

What a man thinking of installing an electric furnace first asks for, in general, is a classification of electric furnaces into good and bad ones. When stripped of its flavor of morality, this means simply a distinction between commercially successful and unsuccessful furnaces. Yet a certain type of furnace may be eminently successful in practice for certain purposes and still prove unsuitable in other fields. Inversely the lack of success in one field does not prove that a new type of furnace will not find elsewhere its real field of usefulness. Hence it would seem that all that is needed and can be truthfully given is a statement of fact of success or lack of success in special well-defined cases. Of what use would any general classification of electric furnaces then be for practical, non-academical purposes?

Yet an unbiased classification is always useful, showing the casual interrelation of the various types. The distinction between arc and resistance furnaces is the natural one academically; it has proven good enough even commercially for patent lawyers and experts in long drawn-out suits concerning the difficult question whether a certain furnace was of the resistance or arc type.

Free from such ambiguity, yet not so very different in the last analysis, is a classification based not on the modus of producing the electrical heat but simply on the place where the heat is generated. We can distinguish three classes. First, in the one extreme case the charge is heated purely from the outside. Typical examples are the Stassano radiation arc furnace for steel refining and the Fitz Gerald-Thomson radiation resistor furnace for zinc smelting. In either furnace the heat is produced entirely outside of the charge under treatment and transferred to the charge by radiation.

The second class is the other extreme case in which the heat is produced entirely within the charge, where there is no heating from the outside whatsoever. This is the class of resistance furnaces either with terminals (electrodes) or without them (induction furnace), the charge itself forming the resistor in either case.

The third class comprises all those numerous cases in which there is heating of the charge both from the inside and the outside of the charge. This class comprises all combined arc and resistance furnaces. In some cases, like the Heroult steel furnace or even the Girod steel furnace, the effect of heating the charge from the outside by the arc is so predominant that the inside heating effect by resistance is practically negligible.

Now this classification may be carried a little further in a manner which is not uninteresting from a practical viewpoint. If we make the place of the heat generation the distinguishing feature we are led at once to the distinction between heating the charge from above, heating it from the sides, and heating it from below. All arc furnaces necessarily employ heating from the top. Heating from the bottom or from the sides is possible only in resistance furnaces. Heating from the bottom is

employed, for instance, in the Hering pinch furnace and in the Natusius steel furnace. Typical examples of heating the charge from the sides are the Acheson furnaces, while in steel refining it is only in the Röchling-Rodenhauser furnace that heating from the sides is employed. There is nothing revolutionary about this whole classification, but it may not be unsuitable for practical discussions.

#### The Ultimate Objects of Engineering Education.

The ultimate object of all education is to make men. That this remains true even in these days of far-reaching specialization is impressively brought out in two commencement addresses, published in this issue—one delivered last year by Mr. David H. Browne, at Queens University, the other last month by Mr. William L. Saunders at the Colorado School of Mines.

Mr. Browne's address was originally intended as a forcible "answer to Mr. Crane," but in the conclusion of his speech the able metallurgist of the Copper Cliff smelter gives a wonderfully inspiring and clear-cut positive statement of what more than anything else the university or college graduate should take along with him into life—culture, friendship, inspiration.

One single phase of this trio was the subject of Mr. Saunders' not less able address dealing with "culture in the education of engineers." There is too marked a tendency on the part of engineering students to devote their time to what they regard as the "practical" part of their course. Too often they fail to see the value of culture, and neglect the study of subjects which make a well-developed and normal man. They fail to "acquaint themselves with the best that has been known and said in the world." They do not develop habits of good speaking and correct writing, and consequently neglect the only means of communicating their ideas in a pleasing and effective manner.

We may less stress for a moment on one single point on which too little stress is generally laid—the value of good technical writing, the ability to express concisely our ideas or the results of our observations. Engineering is a profession of precision, and the tools of expression used in conveying engineering knowledge must be appropriately chosen and accurately used. Under any other conditions an attempt at technical writing becomes abortive, for the reader may be left in doubt just when he should be accurately and adequately informed. Hence laxity in technical expression is sometimes worse than useless—it may be misleading.

The Michigan College of Mines has made a commendable beginning toward educating its students in the art of English expression. Colorado has been doing something along this line, and at the last meeting of the board of trustees additional appropriation was made to extend the facilities for teaching English composition. Other institutions doubtless are considering this work, and we hope that the next few years will see a wide extension of instruction in English composition in our technical schools.

#### Some Aspects of the Steel Production Rate.

Two or three months ago the production of steel in the United States reached a new record rate, a fact which is of profound significance. General business conditions in the

United States are not particularly good, if one make a composite of the views expressed by various authorities. We must not, of course, take such a composite view too seriously, particularly if we desire to use it for comparison with the situation in the steel industry, for it requires little penetration to observe that these views as to the state of general business are derived more from a contemplation of the profits involved than from a measure of the volume of trade. For the steel industry, it is distinctly in tonnage, and emphatically not in profits, that a new record rate has been reached. The earnings are regarded as quite unsatisfactory. As to the state of general business, it may be observed that commodity prices are practically at the highest average upon record and that labor is very scarce. Possibly these elements exist contemporaneously with poor, or but moderately good business, but if so they are keeping very strange company.

The external relations of the high rate of steel production, however, are mentioned only en passant; it is the internal relations which we particularly desire to consider. To define the position first, it may be observed that the steel works in the past two months have been producing pig iron at the rate of approximately 22,750,000 tons of pig iron per year, steel ingots and castings at the rate of between 31,000,000 and 33,000,000 tons per year, and finished rolled steel at the rate of 24,000,000 or 25,000,000 tons per year. The steel ingot rate is convenient for comparative purposes, but is not of commercial importance, since ingots are not a commercial commodity, and the tonnage is excessive on account of the return of scrap produced in rolling.

The current rate of production may first be compared with the previous record. This was attained early in 1910, just after the close of the six or seven-month period of heavy buying, with advancing prices, which followed the slump in prices early in 1909 attendant upon the abandonment of the co-operative policy among sellers of steel. The high point in the productive rate at that time was represented by a rate of about 21,000,000 tons of pig iron per year by the blast furnaces of steel works, a rate of about 30,750,000 tons of steel ingots and castings, and about 23,500,000 tons of finished rolled steel. There have, therefore, been measurable gains shown by all these factors, from 4 to 9 per cent, the greatest gain being in pig iron production. The excess in this item is due to the fact that in the past two years the steel works have become more self-contained, producing a greater proportion of the iron they consume, and buying less from merchant furnaces. The large steel works now produce practically all the pig iron they consume, and the trend among the smaller steel works is towards the building or purchase of blast furnaces.

At the time of the previous record production rate, the steel produced was not all passing into final consumption. The fact may not have been generally recognized at the time, but it forced itself upon attention later, that there had been much speculative buying, induced by constantly advancing prices, so that consumption did not measure up to the high rate of production then reached. It may perhaps be somewhat unsafe to attach too much importance to the apparent difference, but it is the universal claim to-day that the steel which is being produced is also being consumed, and granting that such is the case, steel consumption is to-day more than 10 per cent,

perhaps 20 per cent, in excess of the highest rate reached prior to this year.

When such a position has been reached without a spectacular revival in general industry, it is made quite plain that steel consumption, in relation to population or the general business activities of the people, is represented by a much larger factor than ever before. Such a growth is evidently a normal one, and not the result of special or temporary conditions. It must be due to the progress of the mechanical arts and to the adoption of steel in place of other materials.

Another important aspect of the current rate of steel production is its relation to the existing capacity. It is readily recalled that for practically three years, from late in 1904 until late in 1907, the constantly increasing steel-making capacity of the country was kept in full operation, production increasing simply as available capacity increased. The increase in capacity, however, did not stop with the slump in demand which occurred near the close of 1907, at the time of the great financial panic, but continued uninterrupted. It was then freely observed that capacity had obtained such a lead over consumption that a period of years, perhaps half a dozen, would be required for the overtaking of capacity by demand which has always occurred eventually in this industry. In the winter of 1909-10 there were hopes that demand had overtaken capacity, but while the steel works reached a position of practically full operation, the condition was, as has just been observed, that a considerable portion of the output was a surplus over actual requirements, purchased by buyers because they expected a higher market level to obtain. A survey of operations at present indicates that substantially the full capacity in the majority of instances is fully engaged, exceptions being a few relatively small detached steel works and plants which finish certain descriptions of steel, like wire and tubular goods. These industries are operating at a high rate, but not at their maximum capacity.

Attention should also be given to a somewhat curious aspect of the situation, which is that while the steel industry, now almost fully self-contained, is operating at substantially full capacity, the merchant blast furnace capacity of the country is but indifferently employed. The time was, many years ago, that the market of the merchant furnaces lay largely with the iron mills, and secondarily with the iron foundries. Later the steel works came to supplant very largely the iron mills as pig iron purchasers, and still more lately the steel works have become self-contained, leaving the merchant furnaces, as a whole, little market outside of that furnished by the foundries. It is true the steel foundries have grown up and buy all the iron they make. The large steel works which roll steel occasionally, and many of the smaller steel works regularly, buy merchant pig iron, but on the whole the merchant furnace operator's market has been narrowed continuously. The situation is that the merchant furnaces are making only two-thirds as much pig iron as they did at their last period of greatest activity, somewhat more than two years ago, and the proportion of production to capacity is presumably still smaller. It is regarded as normal that in a revival in demand the demand for steel first asserts itself, and later the demand for products of the foundry, but the observation is not supported by such an array of facts as would ordinarily be desired. There is

reason to conclude that the province of the iron foundry has grown relatively little in a period in which the demand for steel has practically overtaken the capacity.

#### The Proposed Oldfield Revision and Codification of the Patent Statutes.

The public hearings on the Oldfield bill, which has for object to codify and revise the laws relating to patents, have already taken over twenty-eight days; they have thus far been published in twenty-eight bulletins, printed by the Government. These bulletins make intensely interesting reading, and will constitute valuable documents for any technical library. Those who desire to obtain copies of the published hearings should apply to the Clerk of the Committee on Patents, House of Representatives, Washington, D. C., and should ask for copies of the hearings on H. R. 23417 (Oldfield bill).

Never before was so much direct information collected on the subject of the working of the U. S. patent system. A large number of representative men, among inventors, lawyers, manufacturers, business men, have appeared voluntarily before the House Committee on Patents; they have had ample opportunity to present their views orally and in writing, and the chairman of the committee, Mr. Oldfield, has shown unfailing courtesy and patience to all who appeared before him.

It is a noteworthy fact that although there clearly exists a great diversity of opinion among the witnesses as to details of proposed reforms, there seems to be a practically unanimous opinion among those who ought to know best, that the defects of the patent system of this country as it is now, do not reside in the fundamental patent law, but in the way the law is administered before the courts. Lawyers and inventors alike point out that the methods of patent litigation in this country are so absurd, so slow, so complicated, and so expensive, that only rich individuals or wealthy corporations can afford to defend a valid patent against infringers, or to contest the validity of a worthless patent.

From this standpoint, the patent system of the United States, is, as has been said in these columns (see *Abuses of the U. S. Patent System*, by L. H. Baekeland, Vol. X, page 273 (May, 1912) "a godsend for wealthy corporations, lawyers, and experts."

During the hearings, it has been pointed out repeatedly how this could be remedied by adopting the methods of England, Germany, and other countries, and by eliminating the present absurd system of taking testimony in patent suits and by the creation of a single final court of patent appeals, instead of the nine circuit courts of appeal which may render conflicting decisions, so that a patent is declared valid in one circuit and invalid in another.

It has also been stated repeatedly during the hearings how the complications, delays, and expenses of the interference system in the Patent Office give an immense advantage to the party with the well-filled purse, and practically eliminate him who cannot pay for lawyers and experts. This might be easily corrected by awarding priority to the diligent inventor, who first files his application, provided he has made the invention independently, and has not obtained same surreptitiously or by fraud from others. After all, the public is only benefited by the inventor who *discloses* his invention, and not by the

one who keeps his invention secret, until he is compelled to disclose it in interference by another inventor who applies for a patent. The interference system as it is puts a premium on delays and on jokeying in the Patent Office. These are two relatively small reforms; they only relate to rules of practice, yet they would bring about immense changes for the better. They do not touch on the otherwise excellent fundamental patent law; they are no untried things; they are successfully in operation in practically all civilized countries except the United States.

Unfortunately, the Oldfield bill has entirely overlooked these most vital points, and indicates no remedy whatever. What is worse, the Oldfield bill introduces some reforms which, in the opinion of competent critics, will kill off the best parts of the fundamental patent law. These reforms, if adopted, will practically assassinate the very spirit of the United States Patent Law, which hitherto has been generally upheld, by foreigners as well as by Americans, as the best patent law in existence. Nor is the latter statement an idle assumption before the fact that such countries like Germany, whenever they made a change in their patent law, always came a step nearer to the American patent law.

Foreign writers have been unsparing in their praise of the organic American patent law, even if they lost no opportunity to denounce or to ridicule the absurd methods of practice in equity before the courts of this country.

The Oldfield bill, instead of remedying the defects of the patent system, simply mutilates the very best part of the patent law. The bill is evidently aimed at the trusts and some large corporations which have been abusing the patent laws. Animated by the desire of curbing the trusts, the framers of the Oldfield bill have unconsciously proposed means which will favor wealthy corporations more than ever before. Indeed, as was pointed out at the hearings, sections 17 and 32 will still further increase abundant opportunities for expensive and long drawn-out litigation.

Someone has defined an American patent as "a license to enter into patent litigation." By Section 17, an American patent will become "a compulsion to enter into litigation." Anybody who possesses a valuable American patent will constantly run the risk of being harassed, by suits, to give compulsory licenses under some pretext or another. Valueless patents or those of which the value has not been demonstrated or tried will be left unmolested, but as soon as a pioneer has gone through all the efforts and expenses of introducing his invention, and establishing its merits at his own expense, by creating a successful business, then nothing becomes easier for a wealthy competitor than to take away his "exclusive" patent rights, granted as if in sheer mockery by the constitution. By simply inventing an *improvement* on the original invention, and suing the pioneer inventor for a compulsory license, he can easily make him divide his monopoly and make him compete afterwards with the wealthier and more powerfully organized corporation.

If nowadays there is still some possibility for a patentee to compete with large corporations, this will soon disappear if this section 17 passes. This provision is so hopelessly bad, so indefensible, that even the originators of the Oldfield bill seem to admit the dangers thereof.

The compulsory license clause in case of non-working of the patent is just as dangerous an opportunity for business pirates for jumping at the throat of the patentee while he is in the difficulties of pioneer work and saddling him, against his will with expensive compulsory license suits, and to ask him: "Your invention or your business life." Germany at least only allows compulsory licenses in rare cases; for instance, safety appliances or inventions for national defense where the public welfare is involved.

Section 32 is almost as bad, because it takes away from the patentee the right to stipulate conditions under which to license, vend or lease his inventions to others. This section 32 has been aimed specially against resale price restriction; but the framers of the bill have upset unwittingly the very essence of the patent law, and of the provisions of the constitution which guarantee to the patentee, or his assigns, seventeen years of "exclusive right to make, use and vend the invention."

Evidently, those who drew up the Oldfield bill are or were not aware of what an immense amount of mischief and injustice these two sections of the bill would cause, and they remind one of the man who set fire to his barn in order to destroy a hornets' nest. If this Oldfield bill passes as presented, it may be a real calamity for the industrial and intellectual development of this country.

The most eloquent result of the hearings is that among all the many witnesses who have appeared, there was practically unanimous denunciation of Section 17 and Section 32, as framed. One of the very few who were in favor of Section 32, was a lawyer retained by a large Chicago dry goods store, and it was alleged by his critics that this store had frequently violated its business contracts as to selling agreements. On the whole the large majority of those who have given careful thought to the Oldfield bill agree that Sections 17 and 32 would be a great boon to business pirates, habitual infringers, or those who live by appropriating the work or pioneer ship of others.

The single taxer and the socialist may use their arguments against private ownership of landed property which has always existed before it was owned privately and of which the private owner reaps the benefits of the unearned increment conferred upon it by the efforts of the community. Yet the land-owner may let his land lie idle and unproductive to the detriment of his neighbors, and the community at large; furthermore, his title of property or monopoly runs forever.

Why then should an unjust discrimination be made against intellectual property, the most justifiable form of private property, and of which the private ownership exists only for the short period of seventeen years, after which it is confiscated for the benefit of the public?

The status of patent property has been well defined by Albert Walker, in his textbook of patent law: "Patents are property; the owner of a patent is legally and equitably entitled to the same protection that the owner of any other species of property may enjoy. \* \* \* The right of property which an inventor has in his invention is excelled in point of dignity by no other property right whatever. It is equaled in point of dignity only by the rights which authors have in their copyrighted books. The inventor is not the pampered favorite of the Government or of the Nation. The benefits which he confers are greater than those which he receives. He does not

cringe at the feet of power, nor secure from authority an unbought privilege. He confers upon mankind a new means of lessening toil or of increasing comfort, and what he gives cannot be destroyed by use nor lost by misfortune. It is henceforth an indestructible heritage of prosperity. On the other hand, he receives from the Government nothing which cost the Government or the people a dollar or a sacrifice. He receives nothing but a contract which provides that for limited times he may exclusively enjoy his own. Compared with those who acquire property by gift or marriage, compared with those who acquire property by profits or sales or by interest on money, the man who acquires property in inventions, by creating things unknown before, occupies a position of superior dignity. Even the man who creates value by manual labor, though he rises in dignity above the heir, the donee, the merchant, and the money lender, falls in dignity below the author and inventor. \* \* \* *No inventor has any special right in his invention at common law.* This is not a virtue in that law. It is an imperfection, an omission."

Whatever tends to increase and multiply the causes which may involve patent property in litigation, or to render that litigation more complex and ruinous, certainly works to increase the existing insecurity of patent property. The proposed law if made effective would overburden the inventors with litigation uncertainties beyond anything which can at present be estimated.

No one proposes that the principle of compulsory license be applied to landed estates or to any other form of property, however it may have been acquired. Patents are treated as if they were privileges, when, as a matter of fact, a patent to a valid invention of economic and social value is merely a public recognition of an inherent right. If there is reason why the inventors should be compelled to divide their property rights with others, who have in no way contributed to their development, especially along the lines proposed, in sections 17 and 32 of the Oldfield bill, there is even greater reason why the same principle of extraction should be made operative against other forms of private property rights. It does not promote the progress of the useful arts to expose the inventors to dangers which they cannot meet.

It is neither good public policy nor good reason, and certainly not justice, to penalize the inventors because they cannot market their inventions or bring them to the stage of commercial use in the face of legal and economic obstacles created by the long-continued abuse of patent rights and the progressive degradation of the patent system. It is not justice that the inventors should be compelled to surrender their inventive and economic independence, or the prospect of this independence, because society, in its long neglect of their rights, needs, and interests, has permitted a condition to grow up under which the patent system is cunningly and systematically employed to defeat the very aims for which it was created by constitutional provision.

Now that the hearings have disclosed the dangerous mistakes of some of the provisions of the Oldfield bill, it becomes self-evident that this bill ought to be amended considerably before it be submitted again.

If it be redrafted, let provisions be included to simplify and to render less expensive, all actions in equity as well as patent interference proceedings.

#### The Producer and Smelter of Lead-Zinc Ores.

Prices and penalties usually have been the bone of contention between the producers and smelters of mixed lead-zinc ores. The former are quite certain they are being robbed and the latter are sure they are paying all that the market and the grade of the ore will warrant. Whatever right or merit there may be in the customary attitude of the producer, occasionally it becomes quite evident that he does not understand certain fundamental conditions which must always govern the purchase and treatment of these ores.

From Utah comes the plaint that the smelter catches the producer "coming and going." Formerly, when zinc was an undesirable metal in the ores of that State, contaminating in a high degree the profitable lead ores, it formed the basis of a penalty that was exacted by the lead smelters. During that period much ore was left untouched which contained a comparatively high percentage of zinc and little lead. Now, however, when the demand for zinc has made these once rejected ores desirable for zinc smelting, the producer finds that the zinc smelter exacts a penalty on the lead contained therein. Hence the producer feels he is caught "coming and going."

Here are a few points that the producer of zinky lead ores, or leady zinc ores, should remember. Metallurgical processes give the best results and are most profitably operated when applied to ores that are most amenable to them. Zinc smelting and lead smelting are two widely differing processes and neither metal is profitably recovered in the process adapted to the other. Zinc is undesirable to the lead smelter and vice versa. Zinc in a lead blast furnace charge becomes a total loss, in addition to being a source of trouble to the metallurgist; while lead in a zinc charge not only is partly a loss, but that portion which is recovered is saved against the will of the operator, contaminating the resulting spelter and necessitating further refining. In either case the percentage of undesirable metal in an ore must be reduced by mixing the contaminated ore with others that are free from the undesirable metal.

Hence lead smelters usually exact a penalty on each unit of zinc over 10 per cent. Before such ores can be smelted they must be mixed with other zinc-free ores so that the resulting charge will contain from 5 per cent to 8 per cent zinc. On the other hand, zinc smelters lay a penalty on each unit of lead over 5 per cent, because the lead is detrimental to the process, and a charge must be mixed to contain only from 2 per cent to 3 per cent lead.

It is apparent, then, that metallurgical conditions determine in a large measure the basis of payment for zinc-lead ores, and as long as producers persist in shipping undesirable ores they cannot expect the best treatment. They might do better to introduce the intermediate step of concentration, for if an ore contains enough of either metal to make it objectionable to either smelter it probably is worth separating into two desirable products which would command better rates at the different smelters. In this way the producer would not only avoid penalties, but actually get higher rates of payment for both metals. If the ore does not carry enough of the undesirable metal to make it worth concentrating, then the producer may not justly object to penalties, because the smelter can scarcely be said to be making a profit out of the penalized metal.

### Eighth International Congress of Applied Chemistry.

The attention of all intending to acquire membership in the International Congress of Applied Chemistry (which will be held in Washington, D. C., and New York City from September 4 to 13) is called to the importance of qualifying before July 1, 1912, since, according to the rules, copies of the printed report of the Congress cannot be guaranteed to members who will qualify later. The membership fee is \$5.00 and checks should be sent to the treasurer of the Congress, Mr. W. J. Matheson, 182 Front Street, New York City.

All the papers which have been received by July 1 will be printed in advance, and the volumes containing these papers will be ready on September 1.

Some 700 papers have been promised for the Congress. A list of some particularly interesting papers which will be presented before various sections, including the Metallurgical Section, will be given in our next issue.

#### Electrochemistry at the Congress.

An incomplete yet interesting and suggestive list of papers which will be presented before Section Xa (Electrochemistry) is given in a recent press bulletin issued by the Secretary of the Congress, as follows:

Corrosion Tests of a Series of Iron Alloys. By James Ashton, Madison, Wis.

Qualities of Carbon as Influencing Dry Cell Construction. By Carl Hambuechen, Madison, Wis.

Heat Losses in Furnaces. By F. A. J. Fitzgerald, Niagara Falls, N. Y.

Some Analogies in the Electrochemical Industries. By W. McK. Johnson, Hartford, Conn.

Inclusions and Impurities in Electrolytic Silver. By C. D. Buckner, G. A. Hulett and J. Stanley Laird, Princeton, N. J.

Determination of Total Oxygen in Iron and Steel by Means of Carbide Formation. By W. H. Walker and Walter A. Patrick, Massachusetts Institute of Technology.

The Cadmium Coulometer and the Electrochemical Equivalent of Cadmium. By G. A. Hulett and J. Stanley Laird, Princeton, N. J.

Electrolytic Oxidation of Sugar and Oxalic Acid. By Warren K. Lewis, Massachusetts Institute of Technology, Boston, Mass.

Electrolytic Production of Mannite and Sorbite from Invert Sugar. Warren K. Lewis, Massachusetts Institute of Technology, Boston, Mass.

Influence of Cinders on Corrosion of Imbedded Iron. By Walter B. Schulte, Madison, Wis.

Electric Iron Smelting in Scandinavia. By Thomas D. Robertson, Toronto, Canada.

Factors Controlling the Cost of Sodium-Hypochlorite Production. By William H. Walker and Ralph E. Gegenheimer, Massachusetts. By Institute of Technology.

Electric Induction and Resistance Furnaces. By C. H. Vom Baur, New York.

Nouvelle Contribution a la Theorie des Electrolyseurs a Diaphragmes. By Ph. A. Guye, Geneva, Switzerland.

Chemical Reactions on High Temperatures and Pressures. By John M. Pring, Manchester, England.

Power Supply Characteristics of the Electric Furnace. By Charles P. Steinmetz, Schenectady, N. Y.

The Function of Slag in Electric Steel Refining. By Richard Amberg, Crucible Steel Company, of America.

Of considerable interest will be a joint session of the sections on Electrochemistry, Inorganic Chemistry, Physical Chemistry, and Agricultural Chemistry, when an address will be delivered by Mr. Samuel Eyde, of Kristiania, Norway, entitled "Oxidation of atmospheric nitrogen and the development of the resulting industries in Norway." Mr. Eyde is one of the inventors of the commercially successful Birkeland-Eyde process for the fixation of atmospheric nitrogen. This session

will be held on the afternoon of Saturday, September 7, at 2 o'clock, in the American Museum of Natural History.

#### Fall Meeting of American Electrochemical Society.

In this connection the announcement of the Secretary of the American Electrochemical Society is of interest that the fall meeting of the Society will be held in connection with the Congress, Section Xa on Electrochemistry. The joint meetings have been scheduled for September 7, 9, and 10.

On September 7 the American Electrochemical Society will hold a joint meeting in conjunction with the American Institute of Mining Engineers and Congress Section IIIA on Metallurgy, the topic being "Electrometallurgy."

### The Annealed Copper Standard.

A report on copper wire tables has been made by the Bureau of Standards. Copper wire tables are based on certain standard or assumed values for the conductivity or resistivity and the temperature coefficient of resistance of copper. But the same standard values are not in use everywhere, and confusion has accordingly resulted. These conditions led the American Institute of Electrical Engineers to request the Bureau of Standards to make an investigation of the subject. This has been done and has resulted in the establishment of standard values based on measurements of a large number of representative samples of commercial copper—values which in certain respects are more satisfactory than any preceding standards.

In the investigation it was discovered that the temperature coefficient is proportional to the conductivity. This new law has been corroborated by the German Reichsanstalt. Bending and winding a wire do not change the temperature coefficient.

A proposal from Germany of a standard conductivity based upon this investigation has been accepted, and will probably soon be adopted all over the world. This new standard is a slightly lower conductivity than the former American value and the average of the experimental values published by the Bureau of Standards, but can be considered as substantially representative of average commercial copper.

This report gives a history of wire gages, showing that the trend of practice is toward expressing diameters directly in decimal fractions of an inch. The report contains fifteen tables, including complete reference and working tables for annealed copper, both in English and metric units. Tables for copper cables and for hard-drawn aluminum wire are also given. The tables have been adopted as the official wire tables of the American Institute of Electrical Engineers.

### The Iron and Steel Market.

The steel industry probably reached its maximum rate of production for the time being at the beginning of June, as no important additional capacity has since been made active, or is likely to be started in the next few weeks, while hot weather has begun to have its influence in curtailing outputs, and there will be many brief closures in July for necessary repairs. Labor conditions are also being felt as a restrictive influence since there is an absolute shortage of labor, recognized two or three months ago, but now become decidedly acute. Contractors engaged in outside operations find the supply of Italian labor greatly deficient and have been bidding for mill labor with considerable success. A symptom of the labor scarcity is the breaking out of minor strikes at many plants, based upon grievances which do not usually lead to such action.

The current rate of steel production is between 5 and 10 per cent in excess of the highest rate formerly attained, this having been in the early part of 1910. The present rate is well in excess of 30,000,000 tons of steel ingots annually, and may amount to 32,000,000 tons, indicating a rate of between 24,000,000 and 25,000,000 tons of finished rolled steel. The percentage of

existing capacity in operation is slightly less than in the early part of 1910, there having been a very considerable increase in productive capacity in the interim. While steel demand has been very active, on the whole, it has not resulted in absolutely full operation for the reason that it is, naturally enough, not precisely distributed among the different products as productive capacity is distributed. The wire and tubular goods branches of the industry are those which in particular fall short of full operation. Such was not the case in the previous period of great activity, and quite likely the reason is that at that time part of the buying of steel products was speculative. Pipe, in particular, was bought by jobbers far in excess of their current requirements, and stocks were accumulated which required a long time to liquidate. So far as can be observed, the present flow of steel products is exclusively into actual consumption.

The total actual business received by steel mills during June probably exceeded slightly the shipments. The great bulk of the new business was in the form of specifications against contracts. A considerable proportion of these contracts were to expire June 30, and as the prices were below what could be done on fresh contracts and as the mills purposed cancelling unspecified tonnages at the expiration of contracts, buyers have been careful to specify fully. There has been a very moderate amount of strictly new buying in June for early delivery, wants having already been well covered. Of fresh contracting there has been little, except by a few groups of consumers. Agricultural implement makers, who had already contracted for bars for their new season, beginning in July, placed contracts freely for sheets and other materials. The automobile manufacturers began placing contracts for sheets also, paying premiums over the current market on account of the extended delivery period involved.

Prices of steel products have been showing a slight hardening tendency, occasional purchases for prompt shipment being made at premiums, while the balance of probabilities appears to be that a definite advance of \$1 a ton in bars and of \$1 or \$2 a ton in plates and shapes is likely to be announced by the various mills within a very short time.

#### Pig Iron.

The trend of prices has been upwards, but only slightly so. In most markets prices are stationary, though firm, while foundry iron at Cleveland and basic iron in the valleys have advanced during the month by 25 cents. Consumers were already fairly well covered for third quarter, and have not shown much interest in fourth quarter deliveries. Quotations are: No. 2 foundry, Birmingham, \$11 to \$11.50; delivered Philadelphia, \$15.25 f. o. b. valley furnaces, \$13.25; f. o. b. Chicago furnaces, \$14.50; Bessemer, \$14.25, valley; basic, \$13.25, valley. Prompt ferromanganese has eased off slightly, but still commands a premium over the contract prices of \$48.50, Baltimore.

#### Steel.

Unfinished steel has become extremely scarce. Practically all the large mills in the Central West have been out of the market as sellers for some time, but occasionally have been able to spare small tonnages. Until early in June the eastern Pennsylvania mills have had some surplus steel, and in a few instances the rare spectacle has been witnessed of such steel being sold for shipment to the Pittsburgh district, the normal market position being that the freight is against such shipment. While consumers are well covered by contracts, their operations are heavy and deliveries are frequently short, so that there has been a constant demand for billets and sheet bars, but at a price which sellers have not usually been ready to meet. The market cannot be quoted precisely, but the following figures are fairly representative: Billets, \$21.50; sheet bars, \$22, f. o. b. maker's mill, Pittsburgh; billets, \$21; sheet bars, \$22, f. o. b. maker's mill, Youngstown. Wire rods are dull and quotable at \$25, Pittsburgh, a price which it has generally been possible to shade about 50 cents.

#### Finished Steel.

Effective June 1 the National Tube Company reduced its discount on merchant steel pipe and oil country goods, on sizes 6 in. and under, by one point, involving an advance of about \$2 per ton. The independent producers promptly followed. The new discount on "jobbers' carloads," card weight,  $\frac{3}{4}$  to  $1\frac{1}{2}$ -in., is 80 per cent off list. Buyers were well covered by contracts, on which specifications had been fairly liberal, and specifications have since increased, leaving the mills on July 1 with specifications under old contracts for about sixty days' operation.

Current prices, f. o. b. Pittsburgh, unless otherwise stated: Rails, standard sections, 1.25 cents for Bessemer; 1.34 cents for open-hearth, f. o. b. mill, except Colorado.

Plates, tank quality, 1.25 cents.

Shapes, 1.25 cents.

Steel bars, 1.20 cents.

Iron bars, 1.25 cents, Pittsburgh; 1.30 cents, Philadelphia; 1.25 cents, Chicago.

Sheets, blue annealed, 10 gage, 1.40 cents; black, 28 gage, 1.90 to 1.95 cents; galvanized, 28 gage, 2.95 to 3 cents; painted corrugated roofing, 28 gage, per pound, 2.15 cents; per square, \$1.35; galvanized corrugated roofing, 28 gage, per pound, 3.05 cents; per square, \$2.55.

Tin plates, \$3.40 to \$3.50 per 100-lb. cokes.

## CORRESPONDENCE.

#### Determination of Methane in Producer Gas by Means of Copper Oxide

To the Editor of Metallurgical and Chemical Engineering:

Sir:—With reference to the article by S. H. Worell, published in your issue of November, 1911, page 576, permit me to say that the proposed method of determining methane in producer gas by burning the methane to carbon dioxide and water by means of copper oxide, is not new.

As early as 1898 the chemist of the Berlin gas works, Prof. Jaeger, has used copper oxide for this purpose and has even shown that it can be used for the determination of hydrogen and methane in succession by heating first to  $250^{\circ}$  C (whereby the hydrogen is burned to water while the methane is not reacted on) and by heating then to red heat in order to oxidize the methane. This method has been published in the *Journal für Gasbeleuchtung*, 1898, page 764. The apparatus devised for use of this method may be had, for instance, from the Vereinigte Fabriken für Laboratoriumsbedarf in Berlin N.

Two years ago the late great analyst, Prof. von Knorre, used the copper oxide for determining nitrogen in illuminating gas by passing the whole gas over red-hot copper oxide, whereby, with exception of the nitrogen, all constituents of the gas are changed to carbon dioxide and water, so that by introduction into potassium-hydroxide, the nitrogen may be separated.

Since even difficultly fusible glass is gradually destroyed in contact with the copper, Prof. von Knorre filled the copper oxide into a quartz-glass (fused silica) tube. His paper has been published in the *Chemiker Zeitung*, 1909, No. 79.

Technische Hochschule,  
Charlottenburg, Germany.

N. ARNDT.

#### Steel?

To the Editor of Metallurgical and Chemical Engineering:

Sir:—In your May issue, in an article entitled "Steel?" Dr. J. W. Richards proposes that a new classification of iron and steel should be introduced to supersede all the old well known names such as wrought iron, blister steel, ingot iron, mild steel, pig iron, cast iron, etc.

Dr. Richards wishes to subdivide all these different products into two general classes:

Steel = usefully malleable = carbon under 2.2 per cent, and

Cast Iron = not usefully malleable = carbon over 2.2 per cent.

What would be gained by such a classification? As far as I can see nothing would be gained, but much would be lost.

As long as different varieties of that product which is commonly known by the name "iron" exist—and I feel sure these varieties will not only exist but their number will keep on increasing—it will be necessary to distinguish each variety with a special name instead of throwing them all together into a heap from which they again must be picked out and given new names based on the old ones.

I am very much afraid that such a new classification would make matters worse than they are now. Suppose some manufacturer wanted to buy what we now call "wrought iron" and when ordering this from the salesman what should he ask for if he wanted to use the new classification? He should ask for steel, but in order to get the kind he wanted he would have to explain that the "steel" must be very low in carbon, very low in manganese and silicon, it must not be red-short, etc.; but would he be sure to get what he wanted? No, he would be just as liable to get mill steel as wrought iron. How much simpler is it to ask for "wrought iron."

This is only the practical side of the matter. Another reason why I consider Dr. Richards' new classification out of place is that as yet we know too little about the properties of "iron" to be able to introduce a new classification which would not be thrown over in a near future.

Let us wait and see. Perhaps the new electric processes will surprise us with products with new properties. Well, we do not even have to wait for them. The old processes, Bessemer and Siemens-Martin, sometimes surprise the steel-man by putting forth products with very strange properties.

In my practice it has happened when blowing Bessemer (as the process is carried out in Sweden, where the process is stopped when the desired percentage of carbon is reached) that something went wrong with the converter and the heat had to be poured shortly after the process had started; the product attained was a "steel," as it was usefully malleable, but not with less than 2.2 per cent of carbon, but with 4.4 per cent of carbon.

Examples like this one go to show that what we know about iron and steel is mostly the chemical composition and its relation to mechanical properties, but about the physical composition or structure we only know that it has certain influences on the mechanical properties of the product, but we have not yet the power to control and make use of the physical composition or structure, or, as it may perhaps be better called, of the power to regulate the arrangement of the molecules.

I, therefore, propose that the old classification should be kept until we have learned more so that when a new classification is introduced we feel more sure that it really is an improvement on the old one.

AXEL HARTMAN.

*Hardanger Elektriske Jern-og Staalverk, Tysseidal, Hardanger, Norway.*

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To the Editor of Metallurgical and Chemical Engineering.

Sir:—Referring again to Prof. Richards' correspondence on "Steel?" it may be said that the malleability of cocker plates for wire drawing is made use of first, in forging the bar or plate from the ingot and second, in closing up the holes through which the wire is drawn when they are worn too large. They are undoubtedly steel from every point of view.

HENRY D. HIBBARD.

*Plainfield, N. J.*

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To the Editor of Metallurgical and Chemical Engineering:

SIR:—I am pleased that my Norwegian friend, Mr. Hartman has contributed his views on "Steel." His advice to "wait and see" has some force to it, but confusion may become worse confounded while you wait, and reform more hopeless than ever.

I did not propose "to supersede all the old, well-known names"; I distinctly stated that wrought iron would retain its name as a commercial material, and so would all the other varieties named. The sole innovation proposed by me was that all the usefully malleable forms of iron should collectively constitute the great class "steel," each, however, retaining its individual commercial name, as at present. The materials in this class might have less or more than 2.2 per cent of carbon; that definite percentage was named only as a *supplementary* criterion in case doubt existed as to whether the material would be designated usefully malleable, or not.

It follows that the "Cocker plates" cited by Mr. Hibbard would be classed by me as steel since they are forged down from an ingot. As to Mr. Hartman's statement that he made metal in a Bessemer with 4.4 per cent of carbon which was "usefully malleable," he must really permit us to doubt that it was usefully malleable in any ordinary meaning of that term. The burden of proof is distinctly upon Mr. Hartman to prove such a fact—hitherto unknown to iron metallurgists. When the fact is proved I promise not to exclaim, as the countryman did on first seeing a hippopotamus: "There ain't no such beast"; but, on the contrary, I will admit the fact and yet "stick to my guns" to the extent of maintaining that such a material admittedly usefully malleable is not cast-iron, but should be classed as "steel."

I submit that Mr. Hartman's and Mr. Hibbard's illustrations instead of exposing any contradictions in the classification I proposed, simply emphasize its necessity and illustrate its easy, logical and general applicability as the solution of a very difficult question.

*Lehigh University.*

JOSEPH W. RICHARDS.

#### Why Do Many Solids Float on Their Liquids?

To the Editor of Metallurgical and Chemical Engineering:

Sir: According to generally accepted theories heat increases and cold decreases the amplitude of molecular oscillations, giving rise to a change of specific gravity, as the mass remains constant, and the volume of a substance changes with the temperature. In the literature on the subject I cannot find that curves representing the changes in volume and specific gravity of any substances with varying temperature, have been definitely determined. It does not, however, seem probable to me that such a curve would be a regular one, but I think it would show well defined "jogs" and that these would appear most marked, where a change from the solid to the liquid and from the liquid to the gaseous state takes place.

At this point we are confronted with an apparent inconsistency and that is: why do the solids of a substance float on their own liquids, since most of them contract upon cooling, which is evidenced, for instance, in the shrinkage of castings upon solidifying? Two notable exceptions to this rule are water and bismuth, both of which expand on changing from the liquid to the solid state. Still with the majority of substances the rule holds good that the same weight occupies less space in a solid than in liquid condition, and that at the same time its true specific gravity is lower in the former state. We would be very much surprised to see a liquid floating over its own gas, yet I have been unable to find any comment on the fact that most solids float on the liquids of their own kind.

The correct understanding of these phenomena should open up a wide field of investigation particularly to the metallurgist. Take for instance, a metallic alloy; does it not seem possible, in the light of above facts, that a metal of higher specific gravity and higher freezing point should separate by "liquidation" from one of lower specific gravity and lower freezing point, and may not these phenomena account in some measure for the lamellar structure of the eutectic, and shists and gneiss?

I hope that some of your readers will find this subject of sufficient interest to give their views on the matter.

*New York City.*

W. A. C. PAPE.

### The Idol of Quick Returns.\*

The Real Objects of University Education—Culture, Friendship, Inspiration.

By DAVID H. BROWNE.

There are here at Queen's University some 1200 students who have come here to spend from four to six years of their life in the pursuit of some definite object. These students will each spend, perhaps, five hundred dollars a year in railway fares, college fees and living expenses, which means that about \$600,000 a year is expended by these young men and women. In addition to this they have during their time surrendered their earning power and become non-producers. We will assume that during eight months of the year these young people are idle, and that their earning capacity is \$50.00 a month. This amounts to a monetary loss of at least \$400,000 a year. So that I am quite within the bounds of reason when I say that it costs these students at least one million dollars a year to maintain their attendance at this university.

Now, why do they do this? No one pays out money, no one devotes his time, his labor, his ambition in this way without hope of recompense. Ask these boys and girls and they will answer that they do this to be successful in life. Successful in life—this means two things, greater earning ability and greater enjoyment capability. The end of life is happiness. Happiness is not mere Hedonism, not the simple pursuit of pleasure for the sake of pleasure. Happiness means the attainment of man's best, highest, noblest desires. We seek for riches, not for the sake of money alone, but for what we can do therewith to further our physical, mental and spiritual welfare. I take it that these students are here at Queen's in order to gain two things, first, the ability to attain a higher position in life, and second, the capability to enjoy that position when they have attained it.

The first proposition is, then, that these students came here with the idea that when they leave college they will be able to earn more and fill higher positions than if they had never attended college. Is this correct? . . . .

Now Mr. Crane's attack is directed against American technical schools, but it is reasonable to suppose that his arguments are equally applicable to those on this side of the border. There are, however, some important points in which our Canadian schools differ from the American. It is customary in the States to carry on a course of nine months, even in some cases of eleven months' work. On this side our custom is to limit the class work to a period of six or seven months, and to allow the boys to spend three or four months of each year at practical work, in the mine, smelter or shop, according to whatever branches of scientific work they intend to make a specialty of. It has been my privilege at the smelter at Copper Cliff to hire a large number of Canadian students during the summer months. The majority of these are hard-working, diligent, intelligent men, keen to grasp a new situation, and manly enough to accept the discomforts incident to the work in a cheerful way. We are glad to have them there. Those who make good are always welcome again. Of course, as in any other body of men, there are a few goats. I have had a student come to me after a week's work around the furnace and ask for his time, giving as his reason that he wanted to get away, as he had learned all there was about the work, except the details. He got his time.

But the vast majority of Canadian boys are manly and self-reliant. My only regret is that more of them do not

stay with us. Like all other commercial enterprises I know of we are always hard pushed to find among our men some men of intelligence and experience to make foremen. I can assure you that such men are hard to find. Many times we have had to put in responsible positions men who were none too well qualified for these positions, simply because no others were available. What we and many other firms need is bright young men who will remain in our employment, even if their present positions are not to their liking, until we have had time to move them from one department to another in order that they may get a broad experience in their work. But frequently the very man we have talked over and planned to move into some responsible position gets another opportunity offered him elsewhere, and when we want him, he is gone. This fact, which I wish to emphasize, shows very clearly that the demand for such intelligent work as these boys give is greater than the supply.

This fact disposes in very large measure of Mr. Crane's argument that the technical schools turn out a lot of young men who are worthless to their employers, and who can not obtain responsible positions. But Mr. Crane goes on, "these technical school men are not fully trained craftsmen, they are not competent along any line. They come out of college and have to compete with the uneducated laborer, who by sheer dint of sticking to one line of work has mastered that line and is receiving good wages." This is very true. Take a college boy who, after studying, say Electrical Engineering, goes into the shops at Peterboro. He finds men who can do the work he is put at far better than he can, men who know nothing but this particular work. These are his competitors. He has to accept their wage rate, and pit his brains against their experience. He is at a disadvantage for a time. If he considers his present condition only, he may regret that he had not followed Crane's advice, which was to omit the technical school course, go directly into shop, and spend four years of practical training at one line of work.

Now, all I say to this is that if a boy desires to become a highly efficient machine, this is certainly the best way to go about it. The modern shop is always in advance of the technical school; the surrounding influences are all in one direction, and a young man thus spending six years of his life is undoubtedly a better craftsman, and can immediately earn higher wages than one who has spent four or six years in a university.

We will admit once for all that there are some subjects which a university or technical school can not teach, does not attempt to teach, and should not be expected to teach. A university does not aim to make machines, but to make men. It does not take a boy and perfect him along one narrow line. It aims to lay broad foundations, to inculcate principles, to train in culture, to foster taste for all that makes life livable and men and women lovable.

Take this technical school at Kingston for example. If a boy wishes to become a mine foreman, or a smelter man, or an expert winder of commutators, he will never get that training here. Any of his professors would advise him to go into the mines at Granby, or the smelter at Copper Cliff, or into the General Electric works at Peterboro. In four or five years he would be a skilled craftsman, he would earn three or four dollars a day, he might even be in charge of some commercial enterprise—but that is all. He would be successful as he measures success. Like Selkirk on Juan Fernandez, he is monarch of all he surveys, but how far can he survey, how limited his horizon!

Many, many generations have gone by since the preacher said, "Where there is no vision the people perish"—where there is no vision, no broad outlook on life, no scope for larger ambitions. What phrase could better describe the condition of one who spends his best years in mere striving to learn a craft whereby to earn his daily bread. Is this then

\*Extracts from an address delivered at the annual dinner of the Engineering Society of Queen's University, Kingston, Ont., Canada.

†There follows at this place in Mr. Browne's address a long analysis and refutation of Mr. Crane's well-known attacks on university education. As Mr. Crane is now dead and his views are hardly liable to survive him long, this part of Mr. Browne's address is here omitted.—Editor.

all we are to strive for? Is the training we get here simply a meal ticket? I claim that life is more than this. Man cannot live by bread alone. Remember that happiness arises not merely from greater earning power, but from greater capacity for enjoyment.

There are schools, exactly such as Mr. Crane describes, where a man can learn to be a telegraph operator, or a stenographer, a watchmaker, or a barber, and at the end of his training course he comes out a brisk useful craftsman, needing only practice to make him perfect. But what profiteth it a man if he gain the whole world and lose capacity for enjoyment? Wherein is he a gainer if he can earn a living, and his life is not worth living? He can wind a commutator, but he has never heard of Franklin or Faraday. He can cut stone or mix paints, but is blind to the smile of the Venus of Milo or the grace of the Sistine Madonna. He can tune a piano, but is deaf to the pathos of Beethoven and the pious exaltation of Händel. He can survey a wilderness into town lots, but has never lifted his thoughts to Pleiades and the flashing belt of Orion. He has mastered the books of the Scranton Correspondence School, and has never heard of the madness of Hamlet, or the troubles of Tristam Shandy. He can work for a party victory in his own riding and knows not that his liberty to vote was won by Pym and Hampden and William the Silent and Stephen Langton. He is living by bread alone. He has no vision, he cannot see the world as a whole, he has bartered his birthright for a mess of pottage and sold his manhood for a meal ticket.

You are taught many things which may appear to you dry, tedious, irrelevant, uninteresting. Never mind that. You will forget more than you will remember. But always remember this, it isn't the water that stays in the fleece that scours it, it's the water that goes through the fleece. It isn't always what you remember that does you most good, it is the act of grasping new ideas, of fixing the attention, of facing novel problems, of training your brain to act quickly in emergencies. These studies you grind out here are useful, not solely for what you remember of them, but for what they suggest to you.

Mathematics is not, as the beloved Vagabond says, a lot of damned facts about triangles; it is the plan on which the Creator fashioned the universe. Chemistry and biology are not the mere study of reactions and adaptations; they are the keys to all life, past and present. Mining and metallurgy are not hand-crafts; they are factors that open new continents and change the map of the world. French and English are not simply languages in which to call for another wheelbarrow of concrete; they are the open doors to the literature and history, the wisdom and pathos, the wit and humor of a thousand years.

All this broad outlook on life is summed up in one word—culture. No one can give you this, but every college gives you an excellent opportunity to attain it. Culture, friendship, inspiration—these are three things that make life worth living, three things which are here for you to grasp and take with you. Culture, as I have said, comes from study of broad principles and can never be attained by undivided attention to one narrow subject. Here in these halls, among these libraries and museums, you have the chance to attain it.

Friendship, the good-will and affection of your fellows, is here also for you. You cannot dig this out of dead books. Here around you are young men who may be leaders of the future. Learn to know them, find out the best that is in them, be loyal to them, for as the Norse proverb says, "Back is bare without brother behind it." The loyalty you give to the captain on the campus is the same loyalty that has made Canada a great country, and some day will make it, in name as well as in fact, a great self-governed, self-centred nation.

Culture, friendship, and inspiration, these three, and the greatest of these is inspiration. This is the one thing which all the others lead to, for this is the true vision. Inspiration

means the inbreathing of a great spirit, the breath of life in man's nostrils. We cannot define it, we cannot analyze it, we can only feel it as we feel a chord of music. It comes from the consciousness of the presence of the mighty dead who have molded the nation, it comes from the companionship of noble men and women living around us, from the memories with which the college halls are hallowed. You know the feeling that comes over you in a close-packed crowd when the leader arises and you see the tense upturned faces around you and hear the quick intake of breath, as the truth he speaks sinks home. You picture the gaunt figure of Lincoln at the National Cemetery and the hushed audience that hangs on his words as he gives them the greatest speech ever made in the English language, the matchless Gettysburg address. They turn away too deeply moved to applaud, too much uplifted to cheer, because they have received the inspiration, they have seen the vision.

There has been in every college some man around whom the highest and noblest ideas have crystallized, men that have molded the nation; such men are our greatest inspirations. Such men as Arnold of Rugby, Elliot of Harvard, Wilson of Princeton, Angell of Michigan, and fit companion of the greatest, Grant of Queen's—these are the men who have made us men. Can any narrow course of training such as Mr. Crane desires give us anything for which we would exchange these memories? Never. Man cannot live by bread alone.

You will go from here in a few days, less skilled perhaps in the profession you enter than many trained apprentice, you may earn less for a few years than if you had never come here, you will have your struggles as we have all had; but when you do attain your ideals you will have brought with you a greater capacity for enjoyment, a broader outlook on life, a nobler patriotism, and a higher ideal than if you had never spent these years at Queen's, for you will take with you somewhat of these three, culture, friendship, inspiration, to broaden and brighten your life, and you will have glimpsed the vision without which the people perish.

*Copper Cliff, Ontario, Canada.*

### Electrolytic Production of Oxygen and Hydrogen Gases.

In our issue of September, 1911 (Vol. IX, page 471), a full description was given of the process of the International Oxygen Company, of New York City, for the production of oxygen and hydrogen by electrolysis of water.

The following table gives the results of a test recently made by the Electrical Testing Laboratories of New York for the International Oxygen Company.

The object of the tests was to determine the output of four of the cells in actual operation in the plant of the International Oxygen Company at Waverly Park, N. J., in the battery and the corresponding electrical energy required. The four cells tested were selected as being representative of the entire battery after taking a set of preliminary electrical measurements on each of the cells.

All of the data given herewith are from readings as actually observed and corrected for instrument errors. Gas volumes are corrected for moisture and calculated to 20° C. and 760 mm.

Cell No.	Average Amperes.	Average Volts.	Average Watts.	Max. Temp.	Purity of Oxygen	Cu. ft. per hour.		Cu. ft. per hour. Kilowatt hour
						Oxy- gen.	Hydro- gen.	
8	405.1	2.388	967	31.8° C	97.73%	3.247	6.184	3.358 6.395
14	405.0	2.562	1038	30.0° C	98.67%	3.239	...	3.120 ...
66	368.8	2.826	1042	32.0° C	98.46%	2.886	5.788	2.770 5.555
70	392.0	2.660	1043	26.5° C	98.50%	3.082	6.254	2.955 5.900
Average		392.7	2.609	1022	30.1° C	98.34%	3.114	6.075 3.051 5.900

For platinum melting the oxy-hydrogen flame is particularly useful. The International Oxygen Company has introduced for this purpose a torch with a special alloy tip.

## Ammonium Sulphate from Ammonia and Sulphur Dioxide.

### The Extraction of Ammonia and Hydrogen Sulphide from Coal Gases and the Direct Production of Ammonium Sulphate Therefrom Without Using Sulphuric Acid.

BY WALTHER FELD.

For the production of ammonium sulphate the by-product coke oven industry depends at present on the sulphuric acid industry, since the usual method of producing ammonium sulphate is based on the reaction between ammonia and sulphuric acid. This commercial inter-relation is at times very troublesome.

Evidently a great advance would be made if ammonium sulphate could be produced commercially and economically from ammonia and sulphurous acid. The advance would be great if the sulphurous acid were to be obtained from the roasting of sulphides. But the proposition would look even more promising and important if the sulphur contained in gasified coal and a large part of which passes into the gas as hydrogen sulphide, could be used directly for combining with the ammonia in the coal gas for the formation of ammonium sulphate.

For these reasons it is hardly surprising that for a long time attempts have been made to combine directly ammonia and sulphurous acid. Laming tried it as early as 1852 (British patent 14260). But he and others who worked along similar lines, overlooked that the reaction by which ammonia and sulphur dioxide combine will not proceed until it is complete. Neutral ammonium sulphite  $(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$  gives off ammonia and the quantity of the ammonia given off increases with the temperature. The residue is a wet acid salt  $(\text{NH}_4)_2\text{SO}_3 \cdot \text{SO}_2$  which, on air, gives off sulphur dioxide, while only a small part is changed into sulphate. This whole behavior of the sulphites is due to the high vapor tension of both ammonia and sulphur dioxide and for this reason it is an impossibility to absorb completely ammonia contained in gases by means of an aqueous sulphurous acid solution or to absorb completely sulphur dioxide in gases by means of an ammonia solution.

But even if these difficulties could be overcome in practice (which seems impossible), the resulting salt would be of a very unstable nature. To use ammonium sulphite directly as a fertilizer (Lachomette's British patent 17050 of 1887), is impractical for more than one reason, especially on account of its tendency to give off sulphur dioxide and ammonia to the atmosphere. All attempts to change ammonium sulphite into ammonium sulphate by contact with air have been unsuccessful and must be so for good inherent reasons.

### Absorption by Tar Oils

For many years I have been interested in the reaction between sulphur dioxide and hydrogen sulphide, which is rather complicated, although the equation usually and probably erroneously assumed for it



is simple enough.

In the course of our extended researches in this field, my collaborator, Mr. A. Jahl, established the fact that certain tar oils are excellent solvents for sulphur dioxide and sulphur.

Pure sulphur dioxide, introduced into heavy tar oils, is eagerly absorbed with a strong evolution of heat. If this is carried out in a closed bottle with shaking, the reaction is so energetic that the atmospheric pressure above the liquid is considerably reduced, while the temperature rises.

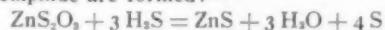
Now, if a tar oil has been saturated with sulphur dioxide and pure hydrogen sulphide is then passed into it, this is also completely absorbed, while simultaneously the temperature increases and the pressure decreases. In this reaction the sulphur dioxide and hydrogen sulphide react, forming sulphur and water, the sulphur dissolving in the hot tar oil.

If now the tar oil is treated alternately with sulphur dioxide and hydrogen sulphide, part of the dissolved sulphur will in time crystallize out of the saturated oil in crystalline grain form.

While this process appears to be very simple, yet it involves great difficulties when applied to gases which contain sulphur dioxide and hydrogen sulphide in great dilution.

### Absorption by Zinc Thiosulphate.

Further experiments showed that hydrogen sulphide decomposes zinc thiosulphate in such a way that zinc sulphide and elementary sulphide are formed:—



If concentrated or dilute hydrogen sulphide is introduced into a solution of  $\text{ZnS}_2\text{O}_3$ , the hydrogen sulphide is completely absorbed. In experiments carried out on a large scale with illuminating gas which was practically free from ammonia, one single washing apparatus was sufficient to absorb 80 to 90 per cent. of the hydrogen sulphide in the gas by means of zinc thiosulphate solution.

The intention was to regenerate the  $\text{ZnS}_2\text{O}_3$  from the zinc sulphide by means of sulphur dioxide, according to the equation



But this regeneration process does not work. First, the zinc sulphide is dissolved very slowly only in sulphur dioxide. Second, the regenerated zinc solution has lost most of its ability of absorbing hydrogen sulphids. The reason is that the regeneration process does not take place as had been supposed, since when zinc sulphide and sulphur dioxide react together, polythionate  $\text{ZnS}_2\text{O}_6$ , instead of the thiosulphate  $\text{ZnS}_2\text{O}_3$ , is mainly formed, and it is a fact for which good physico-chemical reasons may be given, that hydrogen sulphide acts strongly on zinc thiosulphate, but slightly only on polythionate.

In spite of these short-comings, the process indicated a direction in which the work was to be done. It is especially noteworthy that a possibility of absorbing simultaneously hydrogen sulphide and ammonia from the gas was indicated according to the equation:

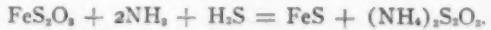


As a matter of fact, experiments showed that not only hydrogen sulphide, but ammonia could be absorbed in this way.

### Absorption by $\text{FeS}_2\text{O}_3$ .

The regeneration difficulty in the use of  $\text{ZnS}_2\text{O}_3$  is overcome by using the iron salt  $\text{FeS}_2\text{O}_3$  instead of the zinc salt for absorption.

The gases which contain ammonia and hydrogen sulphids are washed with  $\text{FeS}_2\text{O}_3$ , whereby iron sulphides are precipitated.

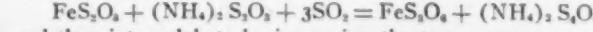


The iron sulphide is dissolved in sulphurous acid forming  $\text{FeS}_2\text{O}_3$  which is again used for treatment of gases:



When the alternate treatment with gas and sulphur dioxide has been repeated several times, the content of the ammonium salt has increased to such an extent that the recovery of ammonium sulphate from the solution becomes profitable.

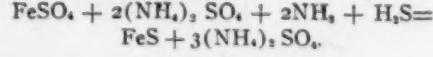
The thiosulphate is now changed into polythionate by treatment with sulphurous acid



and then into sulphate by increasing the temperature

$\text{FeS}_2\text{O}_6 + (\text{NH}_4)_2\text{S}_2\text{O}_3 = \text{FeSO}_4 + (\text{NH}_4)_2\text{SO}_4 + 2\text{SO}_2 + 3\text{S}$ . The heating may be carried out simultaneously with the treatment with sulphurous acid so that the last reaction takes place practically simultaneously with the preceding one.

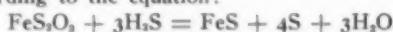
The formation of ferrous sulphate is accompanied by the formation of sulphur dioxide and free sulphur. The free sulphur is burned to sulphur dioxide, while the sulphate solution is again treated with crude gas:



The ammonium sulphate solution is separated from the iron sulphide and concentrated by evaporation.

This process has proven practicable on a large commercial scale and is being used at present in an illuminating gas plant and in a coke-oven gas plant, 60,000 to 70,000 cubic meters of gas being treated daily in each plant.

If there is an excess of hydrogen sulphide over ammonia, no special difficulty is experienced. Hydrogen sulphide alone, without ammonia, reduces ferrous thiosulphate to iron sulphide, according to the equation:



although the low speed of this reaction necessitates comparatively large apparatus when dilute hydrogen sulphide is treated.

On the other hand, the application of this process in such cases in which there is an excess of ammonia over hydrogen sulphide, is impossible without further serious complications.

#### Polythionate Process

In my researches on the physical and chemical properties of metallic thionates, I also paid considerable attention to the behavior of the sodium and ammonium salts. It was found that especially ammonium thiosulphate has the characteristic prop-

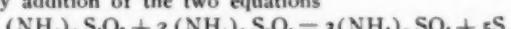
erties of being very easily changed into polythionate by treatment with sulphur dioxide.



and



and by addition of the two equations



That is, when the content of polythionate has reached a certain maximum, then the sulphurous acid which is set free during the sulphate formation, is sufficient to change the present thiosulphate into polythionate and then into sulphate. The precipitated sulphur grains are separated from the sulphate solution for the recovery of crystalline ammonium sulphate.

This polythionate process (British patent 5838 of 1911) represents the simple and reliable solution of the old problem of completely combining ammonia and sulphur dioxide in coke-oven gas or illuminating gas for the production of ammonium sulphate.

In going over the reactions given above, it will be seen that no other oxidizing agent is used besides the atmospheric oxygen

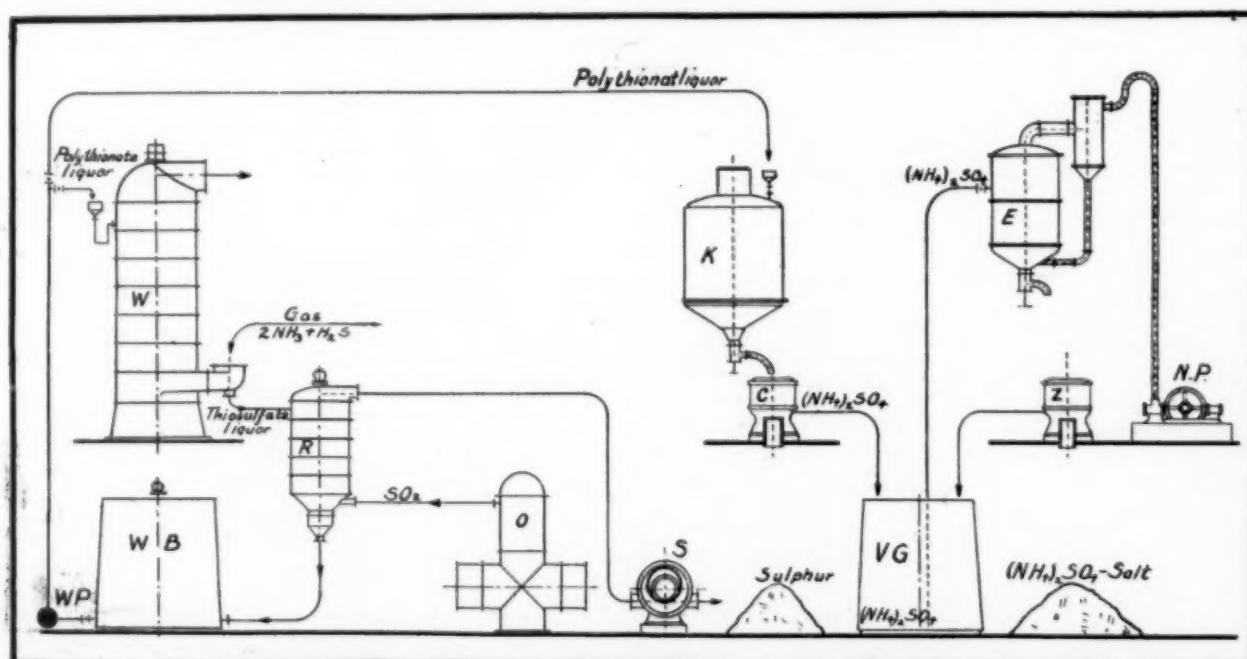


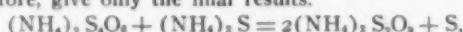
FIG. 1.—DIAGRAM OF APPARATUS AND REACTIONS IN POLYTHONATE PROCESS.

erty of being very easily changed into polythionate by treatment with sulphur dioxide,



This reaction is rapid and complete so that sulphur dioxide may be completely and successfully washed out of dilute gases by treating these gases with ammonium thiosulphate.

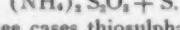
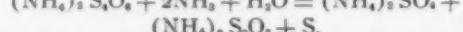
Now, ammonium polythionate is a very effective means for washing out hydrogen sulphide and ammonia, either together or separately. The reactions are probably quite complicated. I, therefore, give only the final results.



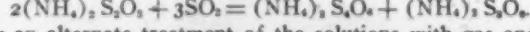
further



and



In each of these three cases thiosulphate is formed, which is changed again by means of sulphur dioxide into polythionate according to our former reaction



By an alternate treatment of the solutions with gas and sulphurous acid, the content of ammonium salts gradually in-

creases. Finally by treatment with sulphurous acid and application of heat, the solution is changed into polythionate and finally sulphate.

#### Practical Operation of the Polythionate Process

Fig. 1 is a diagram of the Feld polythionate process.

*W* is the washer,

*WB* the washer liquor tank,

*R* the regenerator,

*O* the sulphur oven,

*S* the air blower for the sulphur oven,

*K* the boiler,

*C* the centrifugal machine for separation of sulphur,

*VG* the tank for the final ammonium sulphate liquor,

*E* the vacuum boiler,

*Z* the centrifugal for separation of ammonium salt, and

*NP* is a vacuum pump.

The polythionate liquor enters the washer *W* at the top and by the action of ammonia and hydrogen sulphide in the gas, is reduced into hyposulphite solution.

The hyposulphite solution coming from the washer\* enters the regenerator *R* where it is treated with sulphur dioxide. By this treatment the hyposulphite solution is regenerated into polythionate. The polythionate liquor leaves the regenerator *R* and is run into the washing liquor tank *W B*. By the washing pump *W P*, the liquor is circulated constantly as above mentioned, through washer *W* and regenerator *R*, until the liquor has obtained such a strength as is equivalent to a 35 or 40 per cent ammonium sulphate solution. Part of the concentrated polythionate liquor is now pumped into boiler *K* and is here heated by steam. By this treatment, the polythionate in the solution is decomposed into sulphate and free sulphur. The free sulphur separates in form of hard grains which are separated from the ammonium sulphate solution in the centrifugal *C*. The clear ammonium sulphate liquor is run into store tank *V G* and from there into vacuum boiler *E*. By evaporation in the vacuum apparatus, crystals of ammonium sulphate are obtained which are dried by the centrifugal *Z*.

This process is in successful operation in the municipal gas-works in Koenigsberg in Prussia, since June, 1911, dealing with a maximum production of 100,000 cubicmeters (3,530,00 cubic feet) of coal gas per day.

*Linz am Rhein, Germany.*

#### The Non-Ferrous Metal Market.

Since our last report there has been considerable activity in the non-ferrous metal market, and generally higher prices have prevailed. Copper especially has shown a steady advance and lead was advanced considerably by the principal producer. Spelter has held its own at a high figure, while tin has fluctuated on account of the unsettled conditions abroad and the small quantity of metal afloat to this country.

**Copper.**—In spite of the steady advance in price a large volume of business has been transacted both for foreign and domestic consumption. Electrolytic has been in demand, while Lake has not been sold so heavily. The last quotations are 17½ to 17¾ cents for Lake and 17.20 to 17.30 for electrolytic.

**Lead.**—On June 12 the A. S. & R. Co. raised the price of lead to 4.50 cents. Consumption is reported excellent and a further advance is not unexpected. Missouri lead has been selling above its parity with New York. The last quotations show New York 4.50 cents and St. Louis 4.40 to 4.42½ cents.

**Tin.**—The London market has been fluctuating, and the domestic market has been uncertain. At the last reports the London market had risen on account of dock strikes and New York spot tin was quoted at 47½ cents.

**Spelter.**—Considerable business has been transacted for future delivery, but the spot market has been dull. A few deliveries of spot tin have brought premiums. The latest quotations are, St. Louis, 6.60 to 6.75 cents, with a firm market.

**Other Metals.**—Aluminium is quoted at 22½ to 23 cents, New York, with little business transacted. The antimony market also is rather quiet with metal quoted at from 7.10 to 8.10 cents for various brands. Business in quicksilver has been fair and 75-lb. flasks are quoted at \$41, New York, and the same at San Francisco.

#### Annual Convention Colorado School of Mines.

The thirty-eighth annual commencement of the Colorado School of Mines was held in Simon Guggenheim Hall, Golden, Colo., May 24, 1912. Fifty-one students were graduated, forty-eight receiving the degree of Engineer of Mines, one Metallurgical Engineer, and two receiving both degrees. The address was delivered by Mr. William Lawrence Saunders, president of the Ingersoll-Rand Co., New York, who spoke on Culture in the Education of Engineers. This is printed in full on page 427 of this issue.

\*For a description of this washer see the article published on page 436 of this issue.

#### "Pig Steel" Made Directly from Ore in the Electric Furnace.

At a recent meeting in Pittsburgh of the Engineers' Society of Western Pennsylvania Dr. Jos. W. RICHARDS, of Lehigh University, presented a paper on "electric furnace production of pig iron and pig steel." We herewith give an abstract of this paper, which may be found in full in the March issue of the *Proceedings* of the Society.

After some introductory remarks on the pioneer experiments carried out at Sault Ste. Marie under the auspices of the Canadian government on the production of pig iron in the electric furnace (our Vol. IV, pages 124 and 265, 1906), the author referred to the extended work which has been done on this subject in Sweden. Groenwall, Lindblad and Stalhane originated this work. Their leading idea was that within the last few years the price of charcoal in Sweden has doubled, so that their manufacturers are facing the necessity of giving up the manufacture of charcoal iron; they could not import coke, for such fuel would bring their pig iron in direct competition, as regards quality, with the rest of Europe. If therefore the only salvation of their pig iron industry was to continue making pig iron by means of charcoal, the electric furnace was the only chance to save the industry, because in the electric furnace only one-third as much fuel is required, per ton of iron, as in the blast furnace, so that with a limited supply of charcoal it is possible to get three times as much pig iron from electric furnaces as from blast furnaces, and the cost of charcoal figures only one-third as much per ton of pig iron made in the electric furnace as for the pig iron made in the blast furnace.

Dr. Richards reviewed the work carried out by the Jernkontoret (the Association of Swedish Iron Masters), as described in our Vol. IX, pp. 368, 459, 505 (1911); also p. 413 of this issue.

In a critical comparison of the reduction of iron ore in the electric furnace and in the blast furnace Dr. Richards pointed out that the most important point is that the former requires only one-third as much carbon per ton of iron as the blast furnace. When iron oxide is reduced by carbon ( $Fe_2O_3 + 3C = 2Fe + 3CO$ ), the maximum amount of carbon which can be used to reduce the iron oxide to iron is 36 carbon to 112 of iron. Not only is it useless to put more carbon into an electric furnace than is thus theoretically required for reduction, but it is absolutely prejudicial to the running of the electric furnace. On the other hand, in running a blast furnace one can make a ton of iron with a ton of coke, and if foolish enough one can put in a ton and a quarter of coke or a ton and a half and it does not hurt the furnace. The latter works hotter, but it does not stop the operation.

This difference in the behavior between blast furnace and electric furnace is due to the fact that in the electric furnace the excess of carbon accumulates because there is no oxygen to burn it, as the only source of oxygen to consume the carbon is that in the iron ore itself.

This was not understood by the early experimenters, but now the fact is appreciated that a ton of pig iron can be made with about a third of a ton of charcoal and that the more charcoal is used above that, the more difficulties arise in running the electric furnace. When carbon accumulates in the lower part, it lowers the electric resistance of the furnace, makes it difficult to keep it hot, and the best remedy is a dose of iron oxide without any carbon.

In the electric furnace the gas produced is not entirely CO, but CO mixed with CO<sub>2</sub>. If one produced all CO<sub>2</sub> only half as much carbon would be required. While this is impossible, it is possible to produce somewhere about half of CO and half of CO<sub>2</sub>, so that only about three-fourths of the stated amount of carbon is needed in actual practice, when getting down to the real working conditions.

There is a thermochemical anomaly connected with this point to which Dr. Richards drew particular attention. Having a

fixed weight of oxygen to be taken away from a given quantity of iron ore if it is taken away by carbon forming CO, the formation of this CO gives a certain amount of heat, contributed to the furnace. If some of it is changed to CO<sub>2</sub> more heat is contributed to the furnace, because when carbon unites with oxygen to form CO<sub>2</sub> it gives out more heat per unit of oxygen combined than when it forms CO. Therefore, the less carbon is used in the furnace the more heat of oxidation is obtained from it for the same quantity of oxygen or of iron ore. In other words, a fixed weight of oxygen gives out more heat and combines with less carbon when forming CO<sub>2</sub> than when forming CO.

Of course, the more heat assistance is obtained from the carbon the less electric power has to be used. So that the less carbon one can get along with in the furnace for reduction, the more assistance will be obtained from it in a thermal sense, and the less electric energy will have to be used per ton of pig iron. All the experiments that have been made, and all the work of the Swedish furnaces confirm this principle. As they reach economy in carbon and use less fuel, they also use less electric energy, and they thus save at both ends.

As to the power consumption, Dr. Richards thinks that the lowest limit would be one-fifth of an electric horse-power-year per ton of pig iron. In Sweden they have reached one-quarter of a horse-power-year per ton at times for a period of a week or more. The first week in last September the furnace was working well, and then they reached 4 tons of pig iron per horse-power-year (see our Vol. IX, page 482, 1911). Dr. Richards thinks that when a large furnace of perhaps a hundred tons daily capacity is built, and is run with the knowledge which will exist within perhaps five years, the output will probably be raised to 5 tons of pig iron per horse-power-year.

The consumption of electrodes is at present 5 per cent of the weight of the pig iron produced, which is much less than before, representing a great reduction of expense. As to the circulation of the gases Dr. Richards thinks that the use of this method in the Swedish furnace involves more disadvantages than advantages. (See his recent American Electrochemical Society paper in our present volume, May issue, 1912, page 289.)

As stated before, when in these experiments the amount of carbon used for reduction was cut down, the furnace worked better, consumed less power and less carbon, and worked more rapidly, and a pig iron was produced that was white instead of gray. It is well known that as a blast furnace is run faster the tendency is to make white iron. By reducing the amount of fuel and running at a low temperature a product was obtained with 0.1 per cent silicon, 0.1 per cent manganese, and as low as 1.5 per cent of carbon.

To call this product pig iron would be a misnomer. It is called **pig steel**, because in composition it is simply steel. Pig steel is a metal with 2.2 per cent or less of carbon, a very small amount of silicon and manganese, low in sulphur and phosphorus, made directly from iron ore in the electric pig iron furnace. It is not pig iron, it is really crude steel, so it is called pig steel, a name which has generally been accepted. Its German equivalent is "Rohstahl" and in French "Acier brut."

As to the advantages of this material for steel making, the fact that it contains 97 to 98 per cent iron instead of the 92 to 94 in pig iron means that there are only 2 or 3 per cent or less of impurities (instead of six or eight) to be removed in the steel furnace. The steel workers found out at once the advantages of pig steel. Put into the open-hearth furnaces it is converted into steel with half or less of the ordinary refining. The output of open-hearth furnaces using pig steel is increased nearly 50 per cent.

Thus the result has been beneficial all around. The pig iron furnaces makes more of this pig steel in a day than it does of pig iron, and at less cost; the steel furnace makes more steel per day from this material and at less cost. This rather acci-

dental discovery has completely absorbed the attention of the Swedes and Norwegians. They say that not only have they a new process for making pig iron cheaper than in the blast furnace, but they can make a product which they never could make in the blast furnace which is dollars a ton cheaper when converted into steel.

In conclusion Dr. Richards said that in Pittsburgh with its present prices of coal and coke and with power generated by steam or gas it would not be possible to make pig iron as cheaply in the electric furnace as in the blast furnace, but the possibility of producing pig steel in the electric furnace direct from ore may change the situation, although Dr. Richards was noncommittal on this point.

The *Proceedings* of the Society contain a complete abstract of the long discussion which followed the paper.

As to the comparison of cost in the blast furnace and electric furnace in Sweden, Dr. Richards pointed out that the real factor is that they substitute for two-thirds of a ton of charcoal, costing \$8, one-quarter of a horse-power-year costing \$2, and the cost of electrodes. Of course, the furnace is being run on a smaller scale than a blast furnace. A furnace of 2000 kw produces about 18 tons a day. What sort of economy could be had in a blast furnace producing 18 tons per day? The comparison with the blast furnace will become more interesting when we have an electric furnace making 100 tons a day.

Mr. F. F. SNYDER, of Chicago, referred to the possibilities of the electric furnace in foundry practice and gave some of the results which they are getting in a 500-hp electric steel refining furnace which is operating commercially in Chicago on castings. The records of this furnace seem to show that in a properly designed furnace metal can be melted from the cold and refined electrically at a cost very close to the open-hearth cost for the same service and output. He emphasized that rails made from electric steel were becoming a commercial possibility.

Mr. Snyder questioned the advisability of copying the general design of the blast furnace in an electric furnace, especially the necessity of a shaft. Why not do all the reducing in 2 or 3 ft. instead of letting it fall 30 or 40 ft.? Dr. Richards replied that the reason is that when iron is reduced with carbon the first product of that reduction will be CO, and if it has a chance to reduce some further iron oxide some CO<sub>2</sub> may be obtained, and the more CO<sub>2</sub> is obtained the less carbon will be needed in the furnace and the more heat will be obtained from the combustion of the carbon. Therefore, it is desirable to get as much reduction by CO as possible, although it is impossible to cut out the reduction by solid carbon, with which it is necessary to start. The more chance the CO has to pass over red-hot iron oxide the more CO<sub>2</sub> will be produced and the less fuel will be needed. This is the rationale of the shaft, which, however, Dr. Richards believed can be cut down to very small dimensions. If the circulation is cut out and the gases are permitted to slowly filter upwards, 6 or 8 ft. may give them a chance to do all the reducing they can possibly do. Dr. Richards does not believe 40 ft. of shaft is necessary.

Mr. Snyder asked whether the amount of CO<sub>2</sub> which will be formed is not a function of the temperature rather than the height of the shaft. In other words, if the temperature at the top of a 6-ft. shaft is the same as at the top of a 40-ft. shaft the proportion of CO<sub>2</sub> will be approximately the same in both cases. In reply Dr. Richards stated that the temperature is not the only determining factor, but also the time during which the gas is in contact with the ore at that temperature, since the equilibrium which corresponds to that temperature needs time to be established.

**The smelter production of primary copper** in the United States in 1911 was the largest in the history of the country. It amounted to 1,097,232,749 pounds, as compared with 1,080,159,509 in 1910, an increase of about 1.5 per cent. Arizona, Montana, Michigan and Utah were the leading producers.

## The Chemical and Physical Reactions in a Zinc Retort.

By F. L. CLERC.

A charge of roasted ore, mixed with reducing carbon, and moistened with water, is thrown into a red hot retort. When the retort is full, a vent for the escaping steam is made by thrusting a rod along the top of the retort to the end, and quickly withdrawing it. The moisture in contact with the walls is quickly evaporated by the heat conducted through the walls from the flames which encircle the retort.

To escape from the retort, the steam thus formed, must pass through successively cooler portions of the charge.

It is inevitable that some of the water evaporated near the walls will condense in a cooler locality within the retort. At the start some air is entangled with the charge, and the gas issuing from the retort will be a mixture of air and steam. The drying of the charge is a gradual operation, but we can safely say of the current gas passing through any layer of it that it is not only saturated with the vapor of water, but also carries along mechanically any minute globules of water it can entrain on its way to the mouth of the retort; the air being swept out of the retort, the issuing gas is supersaturated steam.

Let it be assumed that the charge is dry, before any particle of the carbon which it contains is hot enough to decompose steam; the issuing gas is then superheated steam, and none being evolved, its current is due to expansion by heat. When a temperature is reached at which the superheated steam can react with hot carbon, other gases are evolved, namely hydrogen and carbon monoxide. So long as any vapor of water is present, this steam continues with diminishing current, until a temperature is reached at which one or other of these new gases reduces zinc oxide. The amount of water vapor present, from which hydrogen is evolved, is very limited, and the action of hydrogen need not be further considered. As soon as the reduction begins, by the reaction  $ZnO + CO = Zn + CO_2$ , two other gases are given off, zinc gas and carbon dioxide. These gases are continuously evolved so long as zinc oxide and carbon are present at a temperature at which this reaction occurs. For the carbon dioxide formed by this first reaction, immediately reacts with the hot carbon, producing twice the original amount of carbon monoxide, as is shown by this (2) equation  $CO_2 + C = 2CO$ , thus replacing the carbon monoxide originally present, and an equal amount which mingles with the zinc, and passes out of the retort. The second reaction occurs at a lower temperature than the first, and must quickly follow it. The mixture of zinc gas and carbon monoxide on its way to the mouth of the retort passes through successively cooler layers of the charge.

Zinc gas, like steam, can be condensed to a liquid. Is there any reason to suppose it will behave differently from the water evaporated in drying the charge? Carbon monoxide does not condense, but some of the zinc must condense to a liquid on the cooler surfaces it meets with.

Are we not safe in assuming that there will pass through every successive layer of the charge a stream of uncondensed zinc gas, mixed with carbon monoxide, carrying along with it any minute globules of liquid zinc which it can entrain by the force of its current?

When such a stream, so burdened, enters the condenser, it passes out of the narrow channels it occupied in the interstices between the particles of the charge, into an open space, through which the liquid globules can subside, and between cooler walls against which the uncondensed zinc will condense, and to which the globules will adhere.

So considered, the condenser of a zinc retort presents an analogy to the device adopted for freeing supersaturated steam from the water it carries with it; and it is not necessary to believe that in the short length of the condenser, less than 2 ft., and in the very short time required to pass through it, the

mixed gases coming out of the retort part with all of the heat needed to keep the zinc in the gaseous state.

In the drying of the charge, water is first evaporated next to the wall of the retort; zinc is also first reduced and volatilized here by heat passing through the adjacent wall, and the evolved gases carry this heat through the rest of the charge. As the zinc is gradually expelled, there remains a porous layer against the wall, through which heat will pass very slowly by conduction. It is, therefore, easy to understand why it is necessary to run the retort hotter according to the time distillation has been going on, and why the rate of distillation varies from time to time, increasing slowly to a maximum, which is maintained for only a small fraction of the length of the shift, and diminishing to a rate which is no longer profitable. Local conditions, such as the value of ore and metal, cost and quality of fuel, quality of fire clay, wages, etc., largely determine the percentage of extraction which should be striven for. The influence of local conditions can be traced in the variations which are found in good practice in all of the following particulars: in the form and size of the chamber in which the retorts are heated; in the method of firing adopted; in the number, shape and dimensions of the retorts, and in the time the charge remains in them.

The object of this minute analysis of the chemical and physical changes occurring within a zinc retort, has been to discover if possible something in practice which can be improved.

Nothing has been shown to indicate that the charge can be heated in any other way than by heat conducted through the wall of an enclosing vessel, which isolates it from the atmosphere and products of combustion. Incidentally it may be noticed that all attempts to smelt zinc by means of heat generated within the charge, by the partial combustion of carbon mixed with it, have met with such practical difficulty in separating and condensing distilled zinc from the accompanying gases that blast processes for zinc smelting may be dismissed from consideration.

No substitute for fire clay, as a material for retorts, has been found. But intelligent effort has been made in very many ways to improve the quality of retorts, as for instance, by the selection of clays; by weathering the raw clays; by varying the proportion of plastic to non-plastic clay in the mixture, or the degree of fineness to which either of them is ground; by increasing the amount of pugging given to the wet mixture; by varying the time allowed for the clay to temper, both in blocks and in the molded retorts before firing, and by varying the heat in firing.

Furthermore, improvement has been sought by substituting for a part of the non-plastic clay, or burnt stock, some other refractory material like crushed quartz, coke, or graphite; by coating the retort within or without, with some infusible and less easily corroded material, such as retort carbon, graphite or carborundum, and particularly by increasing the pressure used in molding the retorts, up to several thousand pounds to the square inch.

I have no desire to minimize the value of what has been accomplished by all of these improvements, but it is evident that no radical advance can be expected on these lines.

Where local conditions permit, great advances have been made in systematizing the manual labor involved in zinc smelting, and supplementing it with machinery.

There remains only to be considered the composition of the charge. No substitute has been found for carbon as the reducing agent; and it may be assumed that every successful smelter is using it, in the form best adapted to his conditions, whether as charcoal, anthracite coal, coke, or non-coking coal. It is well known that some ores are much more easily smelted than others, and therefore more desirable. Without entering into particulars, ores may be classified either according to their richness, that is their zinc contents, or according to their uniformity in composition. The advantage of treating rich ores

is easily seen. The advantage of uniformity is due directly to the fact that when all of the dimensions of a furnace are adjusted for economically smelting ore of a certain zinc content the furnace is not well adapted for doing good work on either much richer or much leaner ores; and is due indirectly to the fact, that the workmen can only get the best work out of the furnace when the charge is sufficiently uniform for them to learn how best to work it off. Uniformity may be secured in a measure by carrying large stocks of ores, and properly mixing them. The concentration of ores, which is usually done near the mines, is really a metallurgical operation; and no judgment of the progress which has been made in the metallurgy of zinc, which overlooked the improvements which have been made on widely divergent lines in the art of preparing the ore for furnace treatment, would be comprehensive or sound. I have recently called attention to fire concentration for some classes of ores as a method of enrichment which appears to offer some attractive possibilities.

Before presenting the numerical results of various calculations of the heat required for the chemical reactions, and changes of physical state which are known to occur within the retort, I think it is well to have in mind some definite idea of the proportions of the different substances which are present at the same time in the retort. From these proportions, whether by weight or by volume, expressions for their relative concentrations may be found.

The capacity of a circular cylindrical retort, whose internal dimensions are 120 C. and 20 C., is 37,700 cu. C. = 37.7 liters. The thickness of its walls is 3 C. and the area of its inner cylindrical surface is 7540 sq. C. A corresponding condenser 50 C. long has a capacity of 7407 cu. C. = 7.41 liters; the thickness of its walls is 1.5 C.

For convenience in calculations, and because I believe it corresponds very closely to actual conditions, I assume that the space which is not actually filled by the solids of the charge amounts to 22,200 cu. C. This is .001 of 22.<sup>22</sup> M<sup>3</sup>, which is the unit of molecular volume for a gas under standard pressure at 0 deg. This unoccupied space, which includes the pores in the charge, I have called the voids. It is equal to the volume of gas present in the retort.

Subtracting the voids from the total capacity, the space filled with solids is 17,700 cu. C., which, with a charge of 21 kg. of 80 per cent ZnO, mixed with 14 kg. of C., figures an average sp. gr. of 2.26. This is considerably less than the average, as figured from their true specific gravities. The bulk is made up by adding lighter inert material, as is common practice. In this limited discussion I consider only the chemical and physical changes occurring within the retort and the condenser. I have assumed that 80 per cent of the zinc contained in the charge is distilled during 15 hours of active production, and that the remaining 9 hours are occupied in cleaning and charging retorts, drying out the charge, and collecting blue powder. The charge then contains 16.8 kg. metallic zinc of which 13.44 kg. is obtained in 15 hours.

Passing now to the gases contained in the retort: If the voids were filled with CO at 0 deg., standard pressure, the weight of CO would be 0.001 molecular volume x 28 kg. = 28 gr. But gases expand by heat and a less weight of this gas would fill the voids at a higher temperature.

At constant pressure, gas expands to 2.83 times its volume, at zero, in going from 0 deg. to 500 deg.; 3.82 times in going to 770 deg. and 4.81 times to 1040 deg. The weight of CO filling the voids will therefore be 10 gr. at 500 deg., 7.33 gr. at 770 deg. and 5.82 gr. at 1040 deg. The weight of zinc liberated by the chemical reaction is directly proportional to the weight of CO produced. The constant ratio is 65/28, that is, if these products do not separate, there will always be 2.32 times as great a weight of zinc mixed with the CO gas. At 1040 deg., zinc is a gas, and its volume is equal to the volume of CO which is present with it. Each gas then fills only half of the voids. Under these circumstances, the weight of CO in the

retort is only half of 5.82 gr., that is 2.91 gr., associated with 6.75 gr. of zinc. At 770 deg. the zinc as a liquid has such a small volume that it may be neglected, and the whole of the voids be considered filled with CO. Thus with the 7.33 gr. CO in the retort at 770 deg., is mixed 17.03 gr. Zn, in liquid globules. With 10 gr. of CO at 500 deg., will be 23.21 gr. of zinc in liquid globules, and with 28 gr. of CO at 0 deg. will be 65 gr. of zinc, solid.

Considering now the conditions at 770 deg., if the 17.03 gr. of zinc is distributed uniformly throughout the CO gas, each of the 22,200 cu. cm of gas contains 0.00077 gr. If this zinc were united in a single liquid globule, it would have a volume of 0.00013 cu. cm whose diameter would be 0.063 cm (0.0252 in.).

There are probably very many liquid globules in one cu. cm of gas, and they must be correspondingly minute. It can be readily seen that they will be carried along by the current of accompanying gas.

If 80 per cent of the zinc in the charge is distilled in 15 hours, 13.44 gr. are distilled in 54,000 sec. = 0.25 gr. per second.

To find the volume of gas which issues from the condenser per second at 500 deg.: since 65 kg of zinc is accompanied by 2.83 times 22.22 M<sup>3</sup> of CO = 62.886 M<sup>3</sup>, we have, 0.25 : 65,000 = X : 62.886 M<sup>3</sup>, from which X = 0.000242 M<sup>3</sup> = 242 cu. cm. If this volume issues through an orifice with a diameter of 6 cm having an area of 28.27 sq. cm it has a velocity of 8.55 cm per second.

This is so slow that it is worth while to test numerical results by another calculation. A discharge of 0.000242 M<sup>3</sup> per second for 15 hours = 13,068 M<sup>3</sup>. The volume of 28 kg of CO at 500 deg. is 2.83 × 22.22 M<sup>3</sup> = 62.886. In 15 hours 13,068/62.88 = 0.208 times this weight is discharged. The corresponding weight of zinc is 65 kg × .208 = 13.52 kg, as against 13.44 kg, with which we started. In practice a large part of the mouth of the condenser is covered, except while metal is being drawn. With a velocity corresponding to 8.55 cm per second, there is a good chance for the liquid globules of zinc to settle out of the gas current in the condenser. Calculation of the average temperature in the condenser, from the conductivity of its walls, determined by measurements of the conductivity of similar material, is apt to give erroneous results; for if it is assumed that the inner surface of the condenser has the average temperature of the gas, this involves an instantaneous and perfect transfer of heat from a gas to a solid, which cannot occur. The alternative is to guess at a probable rate of heat transfer. Moreover, the higher the temperature of the inner surface, for a given temperature of the outer surface, the more rapid is the outflow of heat. It is found that the conductivity required to cool from an assumed initial temperature with a high heat potential differs from the conductivity required to cool from a much lower initial temperature, with a less heat potential, by an amount which does not exceed the probable error of observations of temperature.

Some difference of opinion exists as to what proportion of the heat which is conducted through the walls of the retort is utilized to effect chemical and physical work. When this question is approached from the theoretical side, this difference rises not so much from difference in the physical data employed as from different methods of using them.

For while it is not claimed that all the data used are absolutely correct, it is generally believed that they approximate closely to the truth, and that they are the best available.

To state my case clearly at the outset, so that my argument can be easily followed, I will say here, that I believe the reduction of zinc oxide is effected by carbon monoxide, and that a subsequent reaction takes place, by which the carbon dioxide first formed is reduced to carbon monoxide. It is true that the total heat expended to effect these two endothermic reactions is the same as would be required to reduce zinc oxide directly by carbon, in one operation, if this were possible under the conditions present.

But the method I have chosen brings out clearly how it is

possible that the sensible heat contained in products of the first reaction may help to bring about the second reaction. The external heat required to produce the end products will be less, by exactly the amount of heat in the first products which is thus utilized. Taking then the temperature of reduction to be 1040 deg., we have for the first reaction begun and ended at 1040 deg.

Heat furnished by 81 kg ZnO @ 1040°.. 12,973 kal.

Heat furnished by 28 kg CO @ 1040°.. 7649 kal.

Heat absorbed by reaction ZnO + Co =

Zn + CO <sub>2</sub> (referred to zero) 84,800	
— 68,040	16,760 kal.
Heat contained in Zn gas at 1040°.....	36,894 kal.
Heat contained in CO <sub>2</sub> gas at 1040°.....	13,838 kal.
External heat required .....	46,870 kal.

67,492 kal. 67,492 kcal.

Similarly for the second reaction begun and ended at 1040° we have:

Heat furnished by 44 kg CO<sub>2</sub> at 1040°.. 13,838 kal.

Heat furnished by 12 kg C at 1040°.. 4800 kal.

Heat absorbed by the reaction (referred

to zero) 97,200 — 2 × 29,160.....	38,880 kal.
Heat contained in 56 kg CO at 1040°.....	15,298 kal.
External heat required .....	35,540 kal.

54,178 kcal. 54,178 kcal.

But one-half of the CO formed simply replaces the CO originally present, and the heat which it contains supplies the 7649 kal. furnished by this reagent in the first reaction.

If the two reactions are simultaneous and begin and end at 1040 deg., the heat absorbed by both of them, which amounts to 82,410, must come from outside. If to this sum be added the 12,973 kal. required to heat 81 kg of ZnO to 1040 deg., and the 4800 kal. to heat the 12 kg of C, a total of 100,183 kal. is reached. Of this total, 16,760 + 38,880 = 55,640 kal. has been expended in doing chemical work, and 44,543 kal. is held as sensible heat in the products. If the products leave the retort at this temperature, most of the heat is wasted. But what warrant do we have for thinking that they leave it at anything like this temperature, since it is well known that the second reaction occurs much below this temperature. The zinc in cooling to 500 deg. parts with 31,784 kal., and the 28 kg of CO loses 4133 kal., the total of which is 35,917 kal., which is more than the external heat required for the second reaction. In other words, the total heat required from outside will be reduced by the amount of heat in the products which is expended in effecting the second reaction.

Moreover, if it be granted that the heating of the reagents was accomplished during the several hours of heating up the charge, 17,773 kal. must be deducted from the 100,183 kal. to get the total heat which must be transmitted through the retort during the hours of distillation. This leaves 82,410 as all the heat which must be supplied during distillation; but before reduction begins there is an atmosphere of heated CO in the retort which furnishes 7649 kals. This atmosphere is constantly renewed by one-half the carbon monoxide of this second reaction which replaces it. Only one-half of the sensible heat in the second reaction is carried out of the retort. The remaining 7649 kal. remains and is utilized to repeat the first reaction. Consequently if the second reaction can be effected by the sensible heat contained in the products of the first reaction above 500 deg., it will be necessary to conduct only enough heat through the walls of the retort to bring about the first reaction, and the final products of both reactions will leave the retort at a temperature of about 500 deg.

It should be noticed that most of the heat in the zinc gas is liberated by condensation at 930 deg. This physical change is strongly exothermic, and the heat so disengaged at 930 deg. must be active in the second reaction.

There are theoretical objections against the other hypothesis.

that the gases enter the condenser above the temperature of the volatilization point of zinc, quite apart from the improbability of so intricate a process as condensation being effected in the condenser during the very short time the gas requires to pass through it. I will not discuss them, but after calling attention to the impossibility of any loss of heat from the retort by radiation, which would have to pass out through the hotter walls into the hottest combustion chamber, and the correlative from this, that all the heat present which does not pass out in the products must be expended in doing either chemical or physical work, I will briefly consider the rate of conduction of heat during the hours of active distillation, required to bring about the first reaction. In the case considered, only 0.208 of a molecular weight of zinc is distilled in 15 hours, consequently only  $0.208 \times 46,840$  kal. is required; 9743 kal. in 15 hours = 65 kal. per hour = 1.0833 kal. per minute = .018 kcal. per second. The inner surface of the retort has an area of 7540 sq. cm.

In a retort whose radius is 10 cm, one-half the charge lies in a core whose radius is 7.11 cm. The difference between the two radii may be taken as the average distance the heat must be conducted beyond the walls to reach all of the particles which are reduced. Adding this difference 2.89 cents, to the thickness of the wall 3 cm we have the average distance the heat is conducted 5.89 cm. The amount of heat which is conducted through any resistance, in one second for one degree fall in temperature, is directly proportional to the specific conductivity of the material offering the resistance, and to its area, but inversely proportional to the distance it is conducted. Calling x this conductivity of retort and charge, we have: .018 kcal. per second =  $x \times 7540/5.89 = 0.000014$  thermal ohms. This is very much less than the conductivity found by experiments on burnt fire clay, but it should not be rejected unless it can be shown that sufficient account has been taken of the resistance offered by the break between the retort and the charge, and by the resistance of the porous charge to the flow of heat.

I have used throughout the physical data given in "Metallurgical Calculations," by Dr. Jos. W. Richards, and subjoin the more important:

Heat in 28 kg CO from 0° to t° =  $22.22 [0.303t + 0.000027t^2]$ .

Heat in 44 kg CO<sub>2</sub> from 0° to t° =  $22.22 [0.37t + 0.000022t^2]$ .

Heat in 65 kg Zn from 0 to melting point = 65 [ $0.09058 (420) + 0.000044 (420)^2$ ] kcal.

Latent heat of fusion of 65 kg Zn =  $65 \times 22.61$  kcal.

Heat in melted zinc to boiling point (930°) = 65 [ $0.1275 (930 - 420)$ ].

Latent heat of vaporization =  $23 \times (930 + 273)$ .

Molecular volume of gases at 0° and 76° mm = 22.22 M° using kg.

Molecular heat of combustion Zn + O 84,800 kals.

Molecular heat of combustion C + O 29,160 kals.

Molecular heat of combustion C + O<sub>2</sub> 97,200 kals.

Estes Park, Colo.

**Alcohol from Paper-Mill Wastes.**—In his annual report as chemist to the American Paper and Pulp Association, Mr. Arthur D. Little, of Boston, Mass., summarizes the new devices of the past year looking toward the use of the waste liquors of pulp mills. Perhaps the most important development in this direction, says Mr. Little, is the process introduced in Sweden for the production of an impure grade of ethyl alcohol by fermentation of the waste liquor after neutralization with lime. Although alcohol in considerable quantities can unquestionably be produced in this way, and the process is one involving no serious technical difficulties, it nevertheless unfortunately holds out no hope of avoiding the nuisance created by the waste liquors since the slop from the distillery is far more objectionable than the original waste liquor, because of the presence of great quantities of dead yeast.

### The Magnetic Properties of Alloys.

The sixty-third ordinary meeting of the Faraday Society, held in London on April 23, 1912, was devoted to a general discussion on the magnetic properties of alloys, and was presided over by Sir Robert Hadfield, who in his introductory remarks gave a brief account of the early work in this field, referring more particularly to the non-magnetic ferro-alloys with which he had been associated. He pointed out how magnetic properties depended on heat treatment as well as on composition, and showed a bar of manganese steel which was magnetic at one end and non-magnetic at the other. To illustrate the necessity of working carefully through whole series of alloys before any conclusions could be arrived at, he remarked that whereas a 5 per cent. manganese steel was very brittle and magnetic, the addition of 14 per cent. nickel rendered the steel both very tough and non-magnetic.

#### Magnetic Properties of Iron-Carbon and Iron-Silicon Alloys.

The first paper was read by Geheimrat Dr. E. GUMLICH (Berlin), and dealt with "the magnetic properties of iron-carbon and iron-silicon alloys." The photomicrographs shown were the work of Professor P. Goerens.

The experiments conducted by the Physikalisch-Technische Reichsanstalt, on which the author reported, were commenced a few years ago on the instigation of German technologists and with the joint assistance of the Verband Deutscher Elektrotechniker, some German ironmasters, and the Metallurgical Laboratory of the Technical High School at Aachen (Professors Wüst and Goerens).

The experiments aimed at investigating the relations between the magnetism of iron alloys and their chemical composition and thermal treatment. Although the researches are by no means completed, the Reichsanstalt would like to communicate some of the results obtained to the Faraday Society as a contribution to this discussion. The results concern magnetization up to saturation, coercive force, remanence, and the electric resistance of the alloys iron-carbon and iron-silicon.

Carbon, it is well known, behaves in these alloys in very different ways according to the thermal treatment (slow or rapid cooling) it has undergone, and the differences can be traced in the physical properties, as well as in the structure (cementite, pearlite, martensite, temper-carbon) which is characterised by the presence of the carbon. The carbon which is dissolved in the iron has the strongest influence upon the magnetic properties, and it has resulted that the coercive force of these alloys increases proportionally as the dissolved carbon, while the remanence decreases. These conclusions are important for the manufacture of permanent magnets. The carbon present as impurity plays, however, also an exceedingly important and very disturbing part in the manufacture of dynamo steel, transformer iron, &c., which are to be particularly soft magnetically, because the carbon decreases the permeability and increases the hysteresis loss. Since carbon cannot altogether be eliminated in practice, the manufacturer has to attempt to render it innocuous so far as possible, and the author's experiments demonstrate that a considerable addition of silicon has this effect.

In 1896 Barrett, Brown, and Hadfield published experiments which proved that the addition of silicon to iron diminishes the electric conductivity without impairing the magnetic properties. On the strength of these observations, the Reichsanstalt induced German iron-works to make transformer sheets out of silicon-iron in order to reduce the Foucault-current losses in the transformers. The realized improvement was much greater than was expected; for it resulted that the magnetic properties were generally improved, and the hysteresis losses in particular much reduced. The part which the silicon plays in this improvement is not clear yet. The experiments of the Reichsanstalt show that the influence is not a direct one, for in that case the magnetization should increase with increas-

ing silicon percentage, particularly in fields of high intensity. The saturation value should hence increase whereas it decreases, just as if the silicon were a non-magnetic addition to the iron merely acting by reducing the effective cross-section of the iron. The influence of silicon is hence indirect, and it seems in some way to counteract and to eliminate the detrimental effect of the carbon. For it would appear that on continued heating the carbon cannot remain dissolved in the iron, being transformed partly into the less detrimental cementite, and partly into the altogether harmless temper-carbon.

The microphotographs which Professor Goerens (Aachen) has taken of the magnetically examined specimens are in very satisfactory agreement with the results of the studies of the alloys of iron-carbon and iron-silicon.

#### Magnetism and Stoichiometry.

Professor E. WEDEKIND (Strasburg) then read his paper on "relations between the magnetism and the stoichiometrical constitution of chemical compounds."

The present state of our knowledge concerning the dependence of the magnetic properties of compounds upon the nature and the number of the elements entering into combination may be summed up in the following statements: (1) The magnetism of simple chemical compounds, derived from a ferromagnetic metal or a metal of latent magnetism, is a well-defined molecular property of the compound which is connected with the stoichiometrical composition or with the constitution of the compound. (2) The magnetism of simple compounds of ferromagnetic metals is throughout essentially feebler than that of the metal, so far as independent representations of valencies are concerned. (3) Simple compounds of metals of latent magnetism (Mn, Cr, V, presumably also Ti) are as a rule more strongly magnetic than the metals; the maximum intensity depends upon the stoichiometrical composition, however, particularly in cases where several compounds exist of the same components. Manganese has a maximum in its trivalent state with regard to the elements which can themselves be trivalent, i. e., in the atomic ratio 1 : 1. Some of these compounds behave like permanent magnets. (4) With the independent oxides of manganese, chromium, and vanadium, the susceptibility appears to be a function of the metal percentage, in the case of the vanadium sulphides a linear function of the sulphur percentage; the magnetic susceptibility is thus dependent upon the valency of the metal in the respective compound. (5) So-called mixed oxides or sulphides which do not represent uniform valencies are with all the metals more intensely magnetic than the independent classes of compounds. There is a correlation with the acid nature of the one component, which always represents the higher oxide. Such a compound is always graphically revealed by a sharp bend in the curve. (6) The magnetic susceptibility decreases on the whole with decreasing atomic weight of the chief metal. Several manganese compounds are still ferromagnetic. Of chromium compounds only the two mixed oxides already referred to are still ferromagnetic; none of the vanadium compounds are any more decidedly ferromagnetic. The minimum is probably reached in titanium, which stands to the left of vanadium, and in the titanium compounds which are now being investigated. The next element in succession, scandium, is already diamagnetic as oxide.

#### Magnetism at Low Temperatures.

Dr. JAMES G. GRAY and Dr. ALEXANDER D. ROSS (Glasgow) presented a paper on "the magnetic properties of a variety of special steels at low temperatures," which was read by Dr. Ross.

Specimens of iron, carbon steels, silicon steels, chrome steels, &c., were tested at room temperature and when immersed in boiling liquid air, in the conditions brought about by normalizing, annealing and quenching the metal at various temperatures. It was found that the effect of cooling the specimens

was in general to diminish the permeability for low field strengths, and to increase it for high fields. A magnetization curve corresponding to  $-190^{\circ}$  C. lies initially below and finally above one corresponding to  $15^{\circ}$  C. This is shown to be in harmony with the theory of elementary magnets whose intensity of magnetization and polar length varies with the temperature. It was found that in general the crossing point of the I-H curves corresponding to  $15^{\circ}$  and  $-190^{\circ}$  C. respectively, is higher the greater the amount of the added element present. This rule holds in any of the conditions mentioned above. The value of the magnetizing force necessary to bring about crossing of the magnetization curves for the material at  $15^{\circ}$  and  $-190^{\circ}$  C. is very low in the case of chrome steel. For a specimen of this variety of steel containing 1 per cent. of chromium the curves crossed for a field strength of 8 c.g.s. units.

Cooling to the temperature of liquid air results in the coercive force being increased, and this effect is very pronounced in the case of materials which have been quenched. For high carbon steel in the quenched condition the coercive force at room temperature is 32; at  $-190^{\circ}$  C., it is 50.

#### Heusler Alloys.

Dr. ALEXANDER D. ROSS also read a paper "on the magnetic properties and microstructure of the Heusler alloys."

The paper describes a series of tests on ternary alloys of copper, manganese, and one of the elements aluminium, tin, antimony, and bismuth, and also on several magnetic binary alloys. Details are given of the method of casting and annealing the metal, and a description is given of a special form of magnetometer which was designed in order to increase the accuracy of the tests. The primary object of the magnetic tests was (1) to determine the magnetic quality of the alloys in the condition as cast, (2) to find the best thermal treatment for rendering the metal of good magnetic quality, (3) to test the variation of permeability with temperature, and (4) to investigate the effects of annealing and quenching the alloys at various temperatures. The Heusler alloys are improved by annealing at  $180^{\circ}$  C. The best duration of the annealing process varies from a few minutes to several hours, according to the composition of the specimen. It is found that the effect on the magnetic quality brought about by cooling these alloys to the temperature of liquid air is decidedly different from what is found in iron alloys. The magnetic experiments combined with thermal and microscopic tests have proved that the Heusler alloys are solid solutions probably consisting of  $Cu_3Al$  and  $Mn_3Al$  in the case of magnetic ternary alloys of copper, manganese and aluminium. There is no indication of the occurrence of ternary compounds, and the experiments do not support the theory that the magnetic quality is due to a change brought about in the transformation temperature of manganese through its solution in copper or copper-aluminum.

#### Magnetism of Nickel and Manganese Steels.

A paper by Dr. S. HILPERT (Berlin) and Dr. E. COLVER-GLAUERT (Sheffield) on "the magnetic properties of nickel and manganese steels with reference to their metallographical composition," was read by Dr. Colver-Glaert.

A series of nickel and manganese steels (5 to 33 per cent. nickel and 5 to 10 per cent. manganese) were investigated, by quenching from various temperatures and other thermal treatment, and then quantitatively measured magnetically at room temperatures.

From the products so produced cooling experiments were carried out to  $-180^{\circ}$  C., and the specimens were then reheated in stages to the highest initial temperature employed, and similar magnetic investigations pursued. The following results were obtained:

At high temperatures ( $1,200^{\circ}$  C.) compounds are produced which at room temperatures are strongly magnetic, the only exception being the 33 per cent. nickel steel. This proves that the allotropic theory, which holds that magnetism rests en-

tirely with alpha iron, is no longer tenable as regards these steels, since the slowly cooled steels are less magnetic than those quenched from high temperatures.

The 25 per cent. nickel steel, which most commonly occurs in practice when a non-magnetic alloy is required, was subjected to very close investigation, and a diagram produced showing the magnetic "life" of this steel for all temperatures, and showing the conditions under which its magnetism may vary between zero and maximum. This maximum is practically such as would be expected from a mixture of iron and nickel of the proportions found in the steel. In this steel two irreversible temperature hysteresis loops are found and shown in diagrammatic form. The 33 per cent. nickel steel was found to be quite different to the other iron alloys, and it seems highly probable that steel of this composition must be regarded as a special compound.

Metallographic investigations prove that for these steels it is impossible to correlate any given structure with given magnetic properties. In this investigation sulphurous acid was used as the etching medium, and the structures obtained are different to those usually shown for nickel steels, being much more similar to those of meteoric iron.

The manganese steels were investigated in collaboration with W. Mathesius.

#### Magnetism of Manganese Compounds.

Dr. S. HILPERT and Dr. T. DIECKMANN presented a paper entitled "the magnetic properties of the compounds of manganese with phosphorus, arsenic, antimony and bismuth." This was also communicated by Dr. Colver-Glaert.

The magnetic change points of these compounds were proved to be closely connected with the atomic weights of the substance compounded with the manganese.

The highest is that of  $MnBi$  ( $380^{\circ}$  C.) and the lowest that of  $MnP$  ( $18^{\circ}$  to  $25^{\circ}$  C.). If this latter is warmed in the hand, it no longer reacts with a magnet, but immediately does so if it is placed in cool water. This was experimentally demonstrated.

#### Heusler Alloys.

The following is a summary of a paper communicated by Dr. E. TAKE (Marburg) and Dr. F. HEUSLER (Dillenburg):

1. In order to account for the pronounced ferromagnetism of the Heusler alloys, aluminium or tin-manganese bronzes, Guillaume assumes with Faraday that pure manganese exists in a strongly magnetic modification, which undergoes transformation at a very low temperature; this temperature is said to be raised by the addition of Al or Sn, so that the magnetism of these alloys becomes apparent. This hypothesis is not based upon facts, and the arguments are not sufficiently supported; it would, moreover, not explain the strong ferromagnetism of the Heusler manganese alloys with As, Sb, Bi and B.

2. Heusler, on the other hand, has advanced a hypothesis which perfectly explains all the phenomena; for he has not only discovered the ferromagnetic manganese alloys, but he has also first proved, in 1903, that the appearance of the strong ferromagnetism is due to the formation of chemical compounds, and that the ferromagnetism is thus a molecular phenomenon.

3. It is stated and demonstrated in detail which these strongly ferromagnetic chemical compounds are. (Heusler, Haupt, Preusser, Williams, Ross, Hilpert.)

The research above referred to proves the Heusler Al-Mn bronze to be, in physical respects, exceedingly interesting material, of valuable properties, especially as regards hysteresis.

4a. By the process described by Heusler the malleable Al-bronzes in particular can be converted into an unmagnetic modification which, suitably aged, yields a strongly magnetic material of very small hysteresis. (Heusler, Asteroth, Take.)

4b. By the method of Take the malleable Al-bronzes in particular may, by another ageing process, be transformed into a permanently magnetic modification of high intensity.

5. Hypotheses for explaining the strong ferromagnetism of the chemical compounds on the electron theory have been suggested by Richarz, Weiss and Take.

6. The physical properties mentioned under 4a are due, according to Richarz, to a very slight formation of complexes of the elementary magnets in the one case and to a very pronounced formation of such complexes in the other case.

7. According to his experiments the phenomena of ageing are due, according to Take, to two transformations; the first transformation is the gradual formation of the strong ferromagnetic compound of Heusler; the second is the gradual complex formation, as also suggested by Richarz with regard to the experiments by Heusler and Asteroth. This complex formation also gives rise to the enormous coercive forces which are observed in the case 4b.

Professor A. A. KNOWLTON and Dr. O. C. CLIFFORD (Utah, U. S. A.) also presented a paper on the Heusler alloys.

The paper is a contribution to the study of the following questions:

1. What conditions of preparation and thermal treatment must be observed in order that any alloy of any given composition may be in condition to exhibit the maximum possible intensity of magnetization at saturation?

2. What are the exact relations between composition and the two factors of magnetic quality—hardness, and intensity of magnetization at saturation?

3. Upon what factors does the transformation point of a given alloy depend, and what is the exact form of the relation?

The specimens tested were in the form of rings, prepared by prolonged heating in a graphite crucible and cast in a hot carbon mould. A large series of alloys was made, but either on account of poor mechanical or poor magnetic qualities, tests were confined to the following seven:

No.	Cu.	Mn.	Al.	History.
1	67.8	27.8	4.4	Cast from scrap from many previous specimens. Materials have been often cast and remelted. Chilled from 250°.
3	63.8	27.5	8.7	New mixture. Annealed to room temperature.
4	63.3	26.4	10.3	Cast from scrap. Chilled from dull red heat.
5	63.3	26.4	10.3	From same melt as No. 4, but annealed to room temperature.
6	68.0	28.0	4.0	New mixture. Annealed to room temperature.
7	63.3	29.5	7.2	Al added to No. 6, remelted and chilled from 200°.
8	60.3	25.4	14.3	Al added to No. 7, remelted and chilled from 250°.
9	60.2	26.7	13.1	Remelted from scrap. Chilled from 200°.

The results of the tests show that percentage composition is relatively unimportant in determining magnetic quality as compared with heat treatment. Thoroughness of mixing is also an important factor, difficult to separate from heat treatment. It would appear that under the best conditions of mixing and chilling the maximum possible induction, for a given manganese content, increases with increasing percentage of aluminium. Heusler and Starck's assumption that the best results are given by atomic proportions is not regarded as conclusive. For the details of the experiments made the original paper must be consulted, but the authors conclude that it will be impossible to decide what composition will give the alloy of maximum possible magnetization until the conditions of the best thermal treatment have been worked out over a wide range of composition. Sensitiveness to heat treatment and magnetic hardness are closely dependent upon the proportion of aluminium present, while the transformation temperatures depend largely upon the percentage of copper.

The paper ends with a brief consideration of the following possible hypotheses as to the nature of the magnetic units in the Heusler alloys. These may consist of:

1. The molecules of a chemical compound of manganese and aluminium, or groups of such molecules.

2. Manganese molecules or groups of such molecules.

3. Complex groups, which form the structural elements of a certain type of mixed crystal and contain at least two different kinds of chemical molecules.

#### Magnetism of Iron-Nickel, Iron-Cobalt and Nickel-Cobalt Alloys.

Professor PIERRE WEISS (Zurich) communicated a paper entitled the magnetic properties of the iron-nickel, iron-cobalt and nickel-cobalt alloys.

When the results of quantitative investigations of magnetic properties are considered from the standpoint of the author's kinetic theory of ferromagnetism, all the metals appear to be homogeneous solid solutions. The saturation intensity of magnetism is the resultant—not the sum—of the molecular moments and at absolute zero, when heat movements have ceased to exist, the saturation intensity gives the true moment of the molecule. By molecule the author understands the atoms which are rigidly connected with one another; the atoms may also be articulated, *i. e.*, magnetically free to assume any orientation. In the case of substances like oxygen and the salts of metals (in the solid or dissolved states) the coefficient of magnetization is inversely proportional to the absolute temperature. By multiplying this coefficient by the absolute temperature we obtain the Curie constant, and the molecular moment (which cannot experimentally be determined in these substances) can be deduced from the Curie constant. When the magnetic moment of the nickel atom is followed through varied temperature conditions in the nickel compounds, the moment is found to be represented by multiples of a common factor, 1123.5, which the author calls the "magneton." At absolute zero the magnetic moment of the Ni-atom is  $3 \times 1123.5$ , or 3 magnetons; at temperatures above the Curie point (at which the strong magnetism disappears) it is 8 magnetons, in salts 16 magnetons. The same common factor is found in the magnetic moments of the atoms of Co, Mn, Cr, V, Cu, U, and seem therefore to constitute the common elementary magnet.

The assumption of the existence of these magnetons has proved useful in the study of the alloys of iron-nickel, nickel-cobalt, iron-cobalt, which the author has been investigating in conjunction with G. Foëx, F. Hegg, O. Bloch and A. Preuss. The researches, details of which are given, indicate the existence of the compound  $Fe_2Ni$  (30 magnetons, or 10 per atom) already to be traced on the melting-point curves of Guertler and Tammann, though not recognized by them. In solid solutions the molecular magnetic moment is additive, but not in compounds. Conclusions are also drawn as to  $\beta$  iron (probably  $Fe_2$ ),  $\gamma$  iron ( $Fe_3$ ),  $\delta$  iron ( $Fe$ ). The interpretation of the results appears clear in the case of the reversible  $Fe-Ni$  alloys and of the  $Ni-Co$  alloys; the irreversible  $Fe-Ni$  alloys and the  $Fe-Co$  display complex phenomena. There is, however, also a definite compound,  $Fe_2Co$ , which is more magnetic than pure iron; its technical application is being studied. One of the curious features is that nickel, in its reversible ferro alloys, is in a state which the pure metal only assumes at higher temperature; the surrounding iron molecules thus exert a "repercussion" effect upon the interior magnetic condition of the nickel atom. Cobalt does not affect nickel in the same way, but cobalt has this effect in the alloys of cobalt and iron.

#### Discussion.

The chairman communicated a note in which he criticized the evidence usually brought forward for the existence of a non-magnetic adamantine  $\beta$  form of iron. There might be modifications in the molecular constitution of iron at high temperatures, but that there was allotropy in the accepted sense of the term remained to be proved. There were iron

alloys which were more magnetic than iron, and under the allotropic theory this would mean still another allotropic form of iron. He supported Professor Knowlton's view that ferromagnetism is neither atomic nor molecular, but crystalline, but more light would have to be thrown on the molecular constitution of iron itself before one could generalize on the question.

Professor H. Du Bois opened the general discussion on the papers. He recalled the fact that in addition to the three classical magnetic metals, Weiss has prepared manganese electrolytically, which is ferromagnetic. He next referred to the magneto-optical researches that were being carried out in his laboratory, and he stated that a piece of manganese steel which was non-magnetic as a lump distinctly showed the Kerr effect, the effect being variable for different patches on the mirror which reflected the light. This magneto-optical method affords a means of studying the surface patch by patch. A great many other alloys and compounds which are non-magnetic in the lump also show the same effect.

Professor B. Hopkinson thought that the most promising direction in which to pursue a systematic study of magnetic materials with a view of throwing light on the nature of magnetism was investigation in fields of very high density. Another promising line of investigation was the relation between the saturation value of magnetization determined in that way and the temperature effect. As far as was known at present, the general character of that relation was much the same as that obtaining between the pressure and temperature of a gas or liquid near its critical point, and this was a very illuminating analogy. Experiments in high fields was of value in that accidental effects of structure were eliminated. He had shown, for example, that iron could be stretched far beyond the elastic limit in a very powerful field without changing the intensity of magnetization by so much as 1 per cent.

Dr. W. Rosenhain criticised Professor Hopkinson's statement regarding the "accidental" character of minute internal structure. He considered that while the use of fields of high intensity was of value it would obliterate the effect of many things of interest and importance in themselves. It seemed to him that there were circumstances of a purely molecular character and also of a structural character, and one would have to try to disentangle the two.

As regards the existence of a hard form of  $\beta$  iron, he objected to the use of the word "adamantine," although he believed in the existence of a distinctly harder form of iron which was stable at high temperatures and which could be retained by quenching.

As regards the Heusler alloys, his own work, confined to a range of 11 per cent. aluminium and 10 per cent. manganese, confirmed Dr. Ross's view as to the non-existence of a ternary compound to the cupra-manganese system which explained the magnetic effects of these alloys. The alloys of aluminium alone are strongly magnetic, and consequently the view he took was that the magnetic qualities of the Heusler alloys were due to the presence in them in solid solution of  $Mn_2Al$ . An ingot of this substance would spontaneously disintegrate to a heap of powder, and it was magnetic both in the bar and in the powdery form.

Dr. Cecil H. Desch, in a written communication, suggested that the "ageing" of the Heusler alloys may be a complete effect caused by the formation of inter-metallic compounds, the equalization of composition by diffusion and the union of ultramicroscopic particles of various phases to form physically more stable aggregates. All of these processes may be concerned in modifying the magnetic properties. Further careful investigation of the alloys, made from pure materials, was necessary in a thoroughly well-equipped laboratory and working at high magnifications.

**The late Joseph Dixon**, founder of the Joseph Dixon Crucible Company, is the subject of a biographical sketch by Elbert Hubbard, entitled "Joseph Dixon, One of the World Makers."

### Manufacture of Sulphuric Acid at Ducktown, Tenn.

A bulletin just issued by the U. S. Geological Survey, on "Sulphur, pyrite, and sulphuric acid in 1911," by Mr. W. C. PHALEN, contains as an appendix some notes, by Mr. F. B. LANEY, on "the manufacture of sulphuric acid from smelter fumes at Ducktown, Tenn." The following notes are therefore extracted:

The manufacture of sulphuric acid has solved the problem of taking care of the smelter fumes of the Tennessee Copper Company and the Ducktown Sulphur, Copper & Iron Company, manufacturer of sulphuric acid as a solution of utilizing the sulphur dioxide fumes is, of course, practicable only in localities where there is a market for sulphuric acid, and this is the case in Ducktown, Tenn., in connection with the important fertilizer industry of the South.

The situation became critical a few years ago for the two Ducktown copper companies when the State of Georgia obtained an injunction against them. It was then decided to build acid plants, but the problem involved great difficulties. Both companies were smelting large quantities of ore—the Tennessee Copper Company handling about 400,000 short tons and the Ducktown Sulphur, Copper & Iron Company, about 150,000 short tons annually. In addition to the necessity for handling larger quantities of gas than had ever before been attempted in acid plants, there were the problems to solve of irregularity of supply of gas, variable temperatures, large quantities of flue dust, and, finally, considerable and variable quantities of carbon dioxide gas, in part derived from the ores themselves and in part from the limestone and coke used in the furnace charges.

Work on the plant of the Tennessee Copper Company was begun in 1906, and it was completed in 1907 but not put in full operation until 1908. At this time its rated capacity was 120,000 short tons of 60 deg. Baume acid annually. In 1910 an addition was made which brought the rated capacity up to 180,000 tons yearly, with a probable capacity of over 200,000 tons.

The following account of this plant is taken largely from two articles, one by N. H. Emmons (Copper Handbook, Vol. 10), and one by Wilbur A. Nelson (Resources of Tennessee, Tenn. Geol. Surv., vol. 2, 1912).

The plant as it now stands is the largest sulphuric acid plant ever built. It comprises two octagonal Glover towers, 50 feet high and 30 feet in diameter, with suitable niter pots at the base of each; a flue 10 x 20 x 120 ft. from the Glover towers to cooling chambers; sixty-four cooling chambers 10 ft. 10 in. x 10 ft. 10 in. and 70 ft. high and eight cooling chambers 10 ft. 10 in. x 20 ft. and 70 ft. high; four hard-lead fans, each with capacity of 67,000 cu. ft. of gas per minute; twelve chambers 50 ft. x 50 ft. and 70 ft. high; six chambers 50 ft. x 50 ft. and 75 ft. high; eight chambers 23 ft. x 50 ft. and 80 ft. high having a total volume of 4,600,000 cu. ft.; four Gay-Lussac towers 23 ft. x 23 ft. and 50 ft. high; 4 octagonal Gay-Lussac towers 19 ft. in diameter and 70 ft. high and two octagonal Gay-Lussac towers 36 ft. in diameter and 65 ft. high; acid coolers, pumps, and hoists; and fifteen storage tanks with a capacity of 15,000 tons of acid.

In the construction of this plant 50,000 square feet of asphaltum were put in for flooring under the chambers; nearly 1,500,000 chemical brick, about 300,000 fire brick, and nearly 2,500,000 red brick were used in flues and connections; nearly 8000 tons of quartz for packing the towers, over 500,000 lb. of asbestos in insulating flues; and nearly 8,000,000 lb. of lead in chambers, towers, etc.

In a general way the chambers are of conventional design, but the enormous volume of fumes received and of acid produced have brought about developments new to the acid industry. Among the most notable of these is the size of gas connections, acid lines, acid coolers and fans, all of which are on a scale never before known. Other developments of importance are means for screening the "fines" from the ores; the

erection and operation of a Messiter ore-bedding plant; an increase in size and number of the Gay-Lussac towers; changes in blast-furnace top so as to deliver a uniform supply of gas; the construction of a dust chamber 26 ft. x 36 ft. and 163 ft. long, in which are arranged sets of baffles so as to secure a large dust precipitation; and the construction of an electric acid hoist.

It was discovered that a material decrease in fuel needed in the furnace charge could be made by screening out the fine material from the ores. This also permits a higher oxidation in the furnaces and consequently a higher percentage of sulphur dioxide in the gases.

By means of the bedding plant the furnaces are served with a uniform charge, and at the same time it has been possible to reduce the carbonaceous fuel by about 20 per cent, thereby lowering the troublesome high temperature of the gases and also reducing the percentage of carbon dioxide in the gases from 5 to about 4 per cent.

One of the expensive items in the operation of an acid plant is the loss of nitrogen. The object of the Gay-Lussac tower is to prevent such loss. The exceptionally large towers which were erected in 1910 have proved to be efficient far beyond original estimates in the recovery of the oxides of nitrogen.

The furnace top (Emmons, *Trans. Am. Inst. Min. Eng.*, vol. 41, 1910, p. 723) in use before this acid plant was built, the standard brick top supported by structural steel, was found to be unsatisfactory when the gases had to be dampered back to force them into Glover towers. After much experimental work a simple type of furnace which works very satisfactorily was devised. It has cast-iron corner posts and dividers with walls and ends of fire brick. The half circle top is supported on 20-inch I-beams resting on columns and all metal parts as far as possible are exposed to the cooling influence of outside air. The important features are the large elbow and the flue, 9 feet in diameter, leading to the dust chamber. Flues, elbows, and half circle tops are made of boiler plate with magnesia blocks between the metal and the lining of fire brick.

The dust chamber serves two purposes, it allows a large part of the flue dust to settle, and it conserves and regulates the heat of gases, delivering them at the base of the Glover towers at steady temperature and uniform pressure.

The electric acid hoist has proved itself a very valuable adjunct in raising the acid to the top of the high towers. It is simply a large lead-lined bucket arranged somewhat as a Kimberley skip, electrically controlled throughout. It is believed that this method will effect a saving over the usual blow-case or "acid egg" method. However, it is not intended to supplant the blow cases with the hoist, but to use it with them.

With the enlarged and improved equipment now in operation the Tennessee Copper Company finds that all the ore from its mines is needed to furnish sufficient gas to keep the acid plant up to full capacity. This means that all the gas produced by the green ore furnaces must go to the acid plant, thus completely abating the smoke nuisance.

That the ultimate utilization of the sulphur of their ores was the intention of the **Ducktown Sulphur, Copper & Iron Company** at its organization in 1891 is indicated from its name. The problem was a difficult one and much time was spent in experimental work. The difficulties were finally overcome, and the company is today operating on a satisfactory basis a plant with an estimated capacity of 160 short tons of 60-deg. Baume acid daily. The following notes on the plant are condensed from an article by W. H. Freeland and C. W. Renwick (*Eng. & Min. Jour.*, vol. 89, 1910, p. 1116), and another by Wilbur A. Nelson (*Resources of Tenn., Tenn. Geol. Survey*, vol. 2, 1912, p. 23).

The plant consists of two Glover towers, 12 ft. square and 45 ft. high; a series of dust chambers; four leaden fans; sixteen chambers 96 ft. long, 22 ft. 8 in. wide, and 30 ft. high, having a total volume of 1,050,000 cu. ft.; six Gay-Lussac towers; and the necessary equipment for operating the plant.

From the furnaces the gases pass through flues into a dust chamber. From this chamber they pass into and rise through a cylindrical tower, thence through a kite-shaped flue to a special dust catcher on a higher level. This dust catcher with its system of flues is of special importance in that it controls and regulates the temperature of the gases delivered to the Glover towers and also serves to eliminate the zinc and other light dusts.

From the dust catcher a brick flue runs the full length of the tower building with offtakes to each Glover tower. In these offtakes are placed the niter pots. There is also an auxiliary set of niter pots at the end of the dust catcher for emergency use. In addition to these there are also special methods of handling the nitrogen compounds.

The gases, having been cleaned and reduced to the proper temperature, enter the bottom of the Glover towers. Upon reaching the top of these towers, the gases are led downward through a system of pipes to the base of a special tower through which they ascend and from which they pass through two large lead flues into the chambers. In these towers fully 40 per cent of the  $\text{SO}_2$  is converted into  $\text{SO}_3$ . The concentration of the chamber acid is also accomplished here, and no concentrating pans are needed.

Between the Glover towers and the chambers are located the four large leaden fans which force the gases through the system. The fans are placed in two units of two fans each. One unit forces the gases into the front chambers and the other withdraws them from the rear chambers.

From the chambers the gases pass, as in all acid plants of this type, into the Gay-Lussac towers in which the nitrogen compounds are recovered in the usual way.

This company complies with requirements of the State of Georgia by holding its smelting on a basis to meet the capacity of the acid plant. The ore treated contains from 14 to 19 per cent of sulphur, averaging about 16 per cent.

Although this plant is rated at a normal capacity of 160 tons of 60 deg. Baume acid a day, this does not represent the maximum, as, when actually necessary, it has attained a capacity of over 200 tons a day.

#### "Assisted Research" Fund of the American Electrochemical Society.

In order to further the objects of the American Electrochemical Society as stated by its constitution, it was decided at the meeting of the Board of Directors, held at the time of the Boston convention, to try the experiment of assisting purely scientific research work in electrochemistry where this is done under conditions which would make the application of a few hundred dollars annually of effective and efficient assistance.

For this purpose, \$250 is made available for this year, to be given in whole or in part to help members of the society who need such assistance to carry on some predetermined work.

The committee, which consists of Dr. W. R. Whitney, chairman, Dr. W. H. Walker, and Mr. F. A. J. Fitzgerald, does not wish to burden the scheme with unnecessary rules or requirements, and proposes to carefully consider requests for this assistance on the merits of the case as it may be presented. If the further developments of the scheme warrant the issuing of limitations on the distribution of the fund, such will be published.

The committee's aim will be to give assistance to those who are apparently equipped to do effective work along those purely scientific lines which are not usually explored by commercial or industrial organizations. In other words, the endeavor will be to advance the science of electrochemistry.

The research work thus assisted must be published in the *Transactions of the Society*.

Applications may be sent to the chairman of the committee, Dr. W. R. Whitney, General Electric Company, Schenectady, N. Y., and should be received before August 1.

## Condensers and Condensation for Vacuum Plants.

## Automatic Water-Feed Regulation.

By B. VIOLA, M.E., MEMBER AM. SOC. OF M. E.

The construction and operation of the automatic controlling device by which the results described in my article in the June issue were obtained is shown in Fig. 78. The stem B expands and contracts in response to temperature changes of the condense water. The pipe E supplies compressed air of about 15

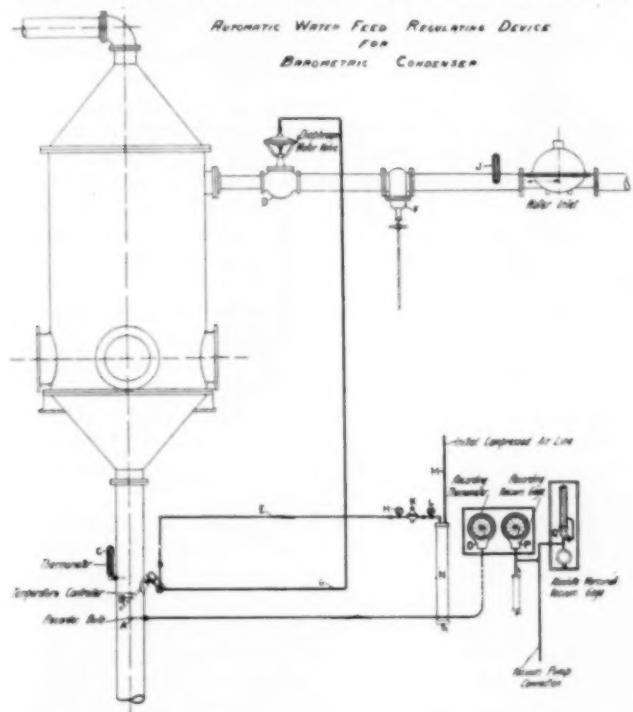


FIG. 78.—AUTOMATIC WATER FEED REGULATING DEVICE FOR BAROMETRIC CONDENSER.

pounds pressure to the valve mechanism of the controller, from which it passes through pipe G to the water-inlet valves, where it actuates a regular globe valve, D, by means of a diaphragm motor which replaces the ordinary hand wheel.

The temperature of the condense water affecting the stem of the controller permits all, a part, or none of the compressed air to pass to the diaphragm-motor valve and consequently the latter is very nearly closed, partly open, or wide open, according to the conditions prevailing, allowing the proper flow of water to the condenser.

Let us assume that the vapor pipe has been delivering an amount of vapor to the condenser which requires such an amount of water as will flow through the inlet valve when the latter is exactly half open. Should now more vapor enter the condenser the temperature of the water passing through the tail pipe will, of course, start to rise, and as soon as the controller stem is affected by this higher temperature it will expand and cause the valve mechanism of the controller to allow less air to flow to the water-inlet valve. Consequently this water valve will act to allow more water to pass through and thus maintain the proper proportion between the volumes of vapor and cooling water.

The auxiliaries are J, a thermometer to indicate the temperature of the cooling water; F, a hand valve for emergency use; C, a thermometer to indicate the temperature of the water passing through the tail pipe and serving as a check on the recording thermometer, which has its bulb at A and its dial at O; and P, a recording vacuum gage, checked by a mercurial absolute-pressure gage, Q.

The initial supply line of compressed air M, which ultimately

operates the diaphragm-motor valve on the water inlet, enters the trap N, where any moisture or sediment is separated and which also acts as a storage reservoir. Gage L shows the initial pressure of the compressed air supply, which is reduced by passing through the reducing valve K to the pressure required for the controller, as shown by gage H.

Fig. 79 shows the very simple construction of the controller by means of a section through A-B. The stem S is in two parts, the outer brass tube and the inner rod. The latter is composed of a material which has an extremely low ratio of expansion and therefore remains of almost constant length, regardless of temperature, while the outer brass tube elongates

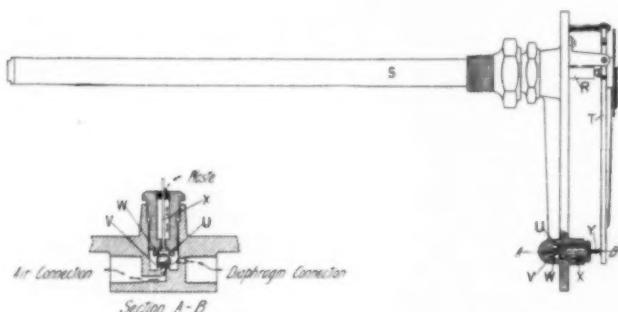


FIG. 79.—CONSTRUCTION OF CONTROLLER.

or contracts in response to temperature changes. The tube and rod are so arranged that they are always in intimate though frictionless contact at the extreme end. R shows the extension of the inner non-expanding member, which recedes when the outer tube elongates and advances when the outer tube contracts.

The movement thus obtained at R is transmitted by the lever T to the valve mechanism shown in cross section. This is simply a three-port valve, shown more clearly in the section A-B, and all ports are controlled by the one ball W. The first port V is the inlet for the compressed-air supply; another port, the second, connects with the line leading to the diaphragm-motor valve; the third port is the outlet for the air which has served its purpose by actuating the diaphragm motor. The position of the ball W depends upon the stem X which is in contact with the lever T at Y. When extension R moves outward, due to the drop in temperature at S, the lever T is raised and the stem allows the ball W to leave port V where the compressed air enters.

The air can then flow through the second port to the diaphragm-motor valve, which starts to close. If a higher temperature acts upon S, expanding the outer tube and turning extension R inward, lever T forces stem X against ball W. The latter then closes port V, shuts off the air supply, and also opens the third port so that the air can escape from the diaphragm-motor. The diaphragm-motor valve consequently begins to open.

In actual practice, the diaphragm-motor valve is only completely closed or wide open if the conditions are such that the tendency is toward a sudden change in temperature. The controller is so sensitive that the diaphragm-motor valve is constantly throttling, that is, letting in just a little more or a little less water as may be required properly to effect the condensation.

If it is desired to change the setting of the controller, to maintain a higher or lower temperature, it is necessary simply to apply a key to the port Z and by turning it one way or the other require extension R to travel more or less before the controller operates.

Fig. 80 shows the diaphragm-motor valve in section. This valve has a regular globe body, with a seal and disc arranged in the usual manner, but with a sliding stem that is operated by the diaphragm-motor. The compressed air enters chamber

C at opening A. This chamber is composed of a cast-iron top B and a rubber bottom D, called the diaphragm. The air pressure forces the diaphragm downward and the saucer E thus forces the stem F downward while compressing the spring G. When the air pressure is relieved the spring opens the valve again.

This installation has been the means of saving about \$400 monthly for over a year in the charges for city water which was formerly wasted.

In Fig. 81 is shown an autographic chart obtained with a temperature controller and applied to a single surface condenser connected to the single vacuum dryer shown in Fig. 52 (this journal, vol. IX, p. 300, August, 1911). With this installation very good results have been obtained and the quantity of cooling water has been decreased from 35 to 50 per cent below that required with hand regulation.

Another construction of an automatic temperature controller for the regulation of

FIG. 80.—SECTION OF DIAPHRAGM MOTOR VALVE.

the cooling water to a counter-current condenser and applied by the author may be seen in Fig. 82. Part 21 is a bulb which contains a volatile liquid and is inserted in the tail pipe through a screwed flange 23 similarly as shown in Fig. 78. The flexible metallic transmission tube 20 connects the bulb 21 with the siphon metallic bellows 16 which operates the cooling water-inlet valve 1. The bulb 21, the metallic tube 20 and bellows 16 are hermetically sealed and confine a liquid which vaporizes at low temperature.

When the water in the tail pipe becomes warm, the vapor generated in bulb 21 forces some of the liquid into the bellows, which expands this by overcoming the counterweight 23 and opens the valve 1. When the water reaches a certain lower temperature, the vapor in the bulb condenses and allows the liquid to flow from the bellows back into the stem so that the bellows now collapses and closes the water-inlet valve.

This regulator can be set for different temperatures by adjusting the counterweight on the lever arm at 27. The variations of temperature of the condens water can be seen on charts Figs. 64 and 70 in my article in the May issue, 1912, p. 268.

To determine the quantity of cooling water the following formula can be used:

$$W = \frac{H - h}{t_1 - t_2}, \text{ where}$$

W = weight of cooling water in pounds necessary to condense one lb. of steam,

H = total heat of steam at condenser pressure and vacuum (which may be taken from a steam table),

h = heat of liquid of the condensed steam (B.t.u.),

t<sub>1</sub> = temperature of condens water (cooling water and condensed steam),

t<sub>2</sub> = temperature of cooling water.

According to the charts Fig. 73 and 75, in my article in the June issue, we may take in average

$$t_1 = 115^{\circ} \text{ F.},$$

$$t_2 = 55^{\circ} \text{ F.},$$

$$H = 1120 \text{ (according to steam table),}$$

$$h = 115 - 32 = 83 \text{ B.t.u.},$$

then it follows

$$W = \frac{1120 - 83}{115 - 55} = \frac{1037}{60} = 17.3$$

or 17.3 lbs. of water was necessary to condense one lb. of steam.

During the 24 hours chart, Fig. 73 = 20,400 c.ft.

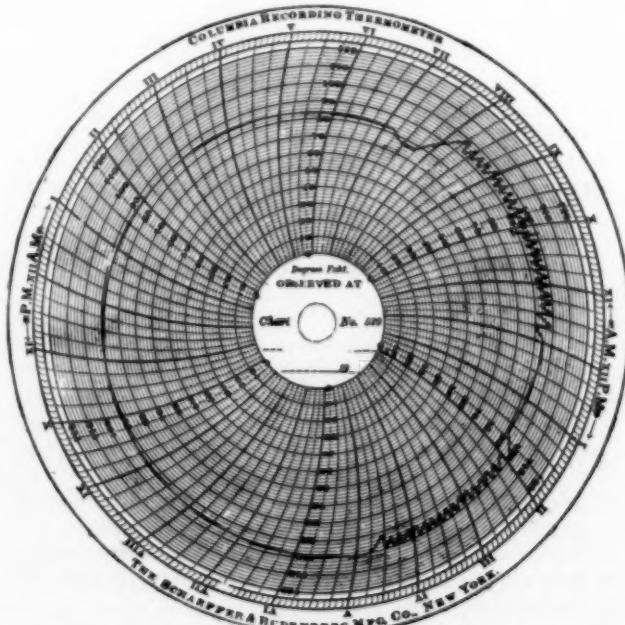
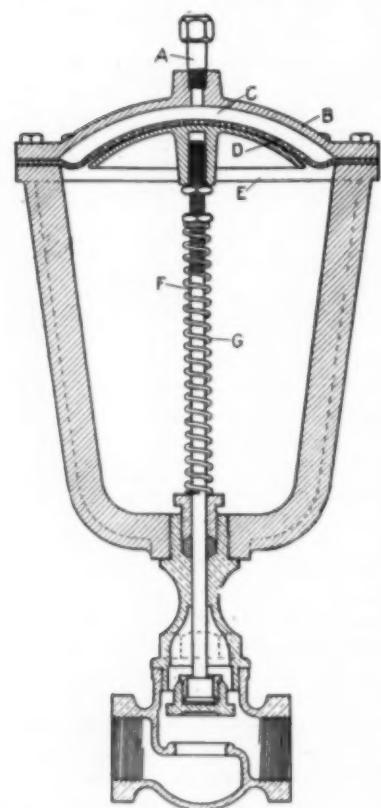
During the 24 hours chart, Fig. 75 = 19,450 c.ft. water was measured by a Thomson water meter and the results have shown that the quantity of the condensed water and vapors of the six connected vacuum pans were nearly correct.

By comparison with chart Fig. 72 in my article in the June issue, where the evaporation in the vacuum pans was considerably smaller, the resulting saving of the cooling water can be easily seen.

In sugar refineries, combined surface and spray condensers are usually employed which are similar to that shown in Fig. 83. The vapor from the vacuum pans first passes through the surface condenser, so that in case the vapor carries along some sugar particles, they will be condensed at that point and can be used to dissolve the raw sugar. In this way nothing is lost. The remainder of the vapor passes to the spray condenser, is condensed, and flows down the tail pipe.

Condensers of this type require a considerable quantity of water and there may be a great waste of water if no controlling device is employed.

Even where salt water is used this waste should not be permitted, because it increases materially the quantity of steam necessary for the operation of the pumps. In many cases where salt water is now used on account of the great quantity required, the use of a well-constructed counter-current condenser operated economically with a precise temperature con-



which it comes from the tail pipe, in spite of the assertion that condens water does not contain any impurities carried over from the source of the vapor. That the opposite is true

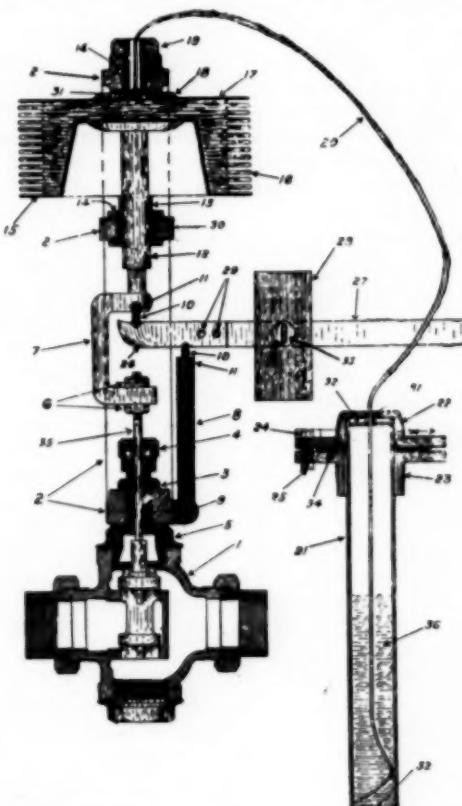


FIG. 82.—SYPHON AUTOMATIC CONDENSER REGULATOR.

can be established in many cases. In steam-engine plants, for instance, it is well known that condensed steam contains oil, etc., and it is never pumped direct to the boilers. Frequent analyses have shown that condens water from vacuum plants does not contain sugar or acid from the evaporation of acid liquor, but the so-called untraceable losses in vacuum plants

This can even be understood by reference to the following simple mathematical formula:  $a \div \infty = 0$ , where  $a$  means a small quantity of material which is evaporated in the vacuum pan, and which is carried over in every case by the vapor into the condenser. Here it comes naturally in contact with very great quantities of water, so great, in proportion, that it is not possible to prove its presence in the condens water. Or in other words, it is divided in so many countless parts, that it is infinitely small. However, as the same formula shows  $0 \times \infty = a$ , or in other words, it is present in the condens water in spite of the contrary assertions.

This is very plainly proven by practical experience.

However, when this condens water at a high temperature (110° to 120° F.) is passed through an efficient water-purifying plant, there is no doubt that it may safely be used for boiler feed. The author has accomplished this and in some later articles will refer to this subject more extensively.

### Surface Combustion

In an article in our issue of December, 1911 (Vol. IX, p. 628) the application of flameless or surface combustion to industrial purposes was described, in connection with several lectures then delivered in this country by Prof. William A. Bone, of England.

The widespread attention which these lectures attracted to the subject of surface combustion, have had the effect of bringing into the foreground some almost forgotten important work done by Dr. CHAS. E. LUCKE, now professor of Columbia University, along similar, if not identical lines, as early as 1900. Dr. Lucke's experiments were described in his paper on The Heat Engine Problem, presented before the Society of Mechanical Engineers in 1901, and two fundamental patents were granted to Dr. Lucke for his process (U. S. patents 755,376 and 755,377, both of March 22, 1904).

These two patents of Dr. Lucke have been bought by Dr. Hugo Lieber, of New York City, who has organized the Gas and Oil Combustion Company, with office and laboratories at 50 East Forty-first Street, New York City, where extensive experiments are being conducted to commercialize Dr. Lucke's inventions under the inventor's supervision. Various tests on larger scale concerning the practical application of these inventions are also being conducted now in several factories under supervision of the Gas and Oil Combustion Co.

In the meantime Prof. WILLIAM A. BONE has delivered another lecture on the subject, this time before the Cavendish Society of Leeds University. The lecture is printed in full in (London) *Engineering*, May 10, 1912.

The feature of the method of surface combustion is that an explosive mixture of gas and air is burnt without flame in contact with a granular incandescent solid. We mention here only the more recent developments of the system.

With a small muffle furnace heating a muffle measuring 9 1/2 in. x 5 1/4 in., the results recorded in table I were obtained. The most noteworthy point, Professor Bone said, was the relatively low temperature of the escaping products of combustion. This was in every case considerably lower than that of the muffle.

TABLE I. RESULTS OF TEST ON A MUFFLE FURNACE.

Dimensions of Muffle 9 1/2 x 5 1/4 x 3 1/4.

Temperature in Middle of Muffle.	Gas Consumption to Maintain Temperature Constant.	Temperature of Products of Combustion.	
Deg. C.	Deg. F.	Cub. ft.-hr. at 15 deg. C. Deg. C.	Deg. F.
815	1449	21.0	540
1004	1840	35.3	645
1205	2201	58.0	870
1424	2596	79.0	1085
Mean net cal. value of gas = 540 B. Th. U. per cubic foot at 15 deg. C.		1598	1985

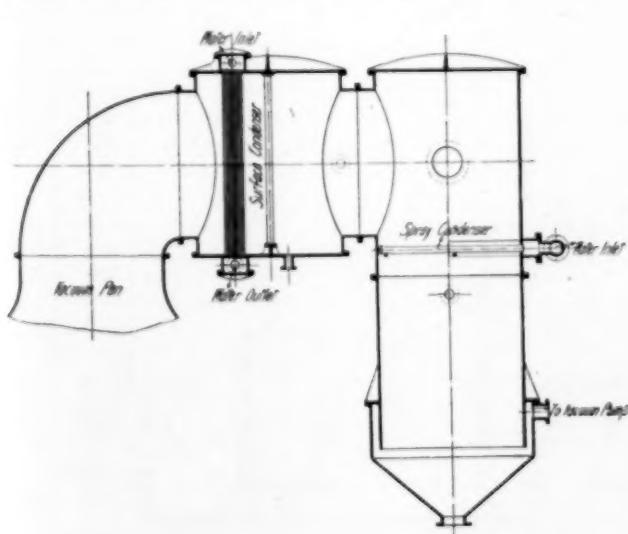


FIG. 83.—COMBINED SURFACE AND SPRAY CONDENSER.

must necessarily be looked for in the condens water. The quantity of water used is so great that the presence of these impurities is not always noticeable, but practical experience has proved them to be present.

Thus with a temperature of 1424 deg. C. at the middle of the muffle, the temperature of the products of combustion was some 300 deg. C. less. There was no appearance of flame at the vent even with the highest temperatures. In some comparative experiments with a good specimen of the ordinary type of muffle furnace, the maintenance of a temperature of 1057 deg. C. required the consumption of 105 cu. ft. per hour

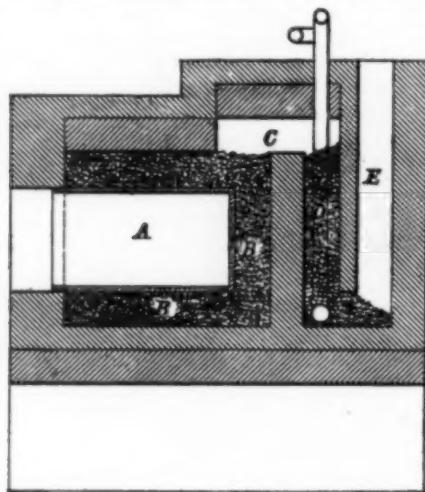


FIG. 1.—MUFFLE FURNACE WITH REGENERATORS.

of the same gas. With surface combustion a consumption of 43 cu. ft. per hour would have sufficed. In a series of competitive trials made in the United States with American gas-fired furnaces, the flameless combustion system required only half the gas to maintain a given temperature.

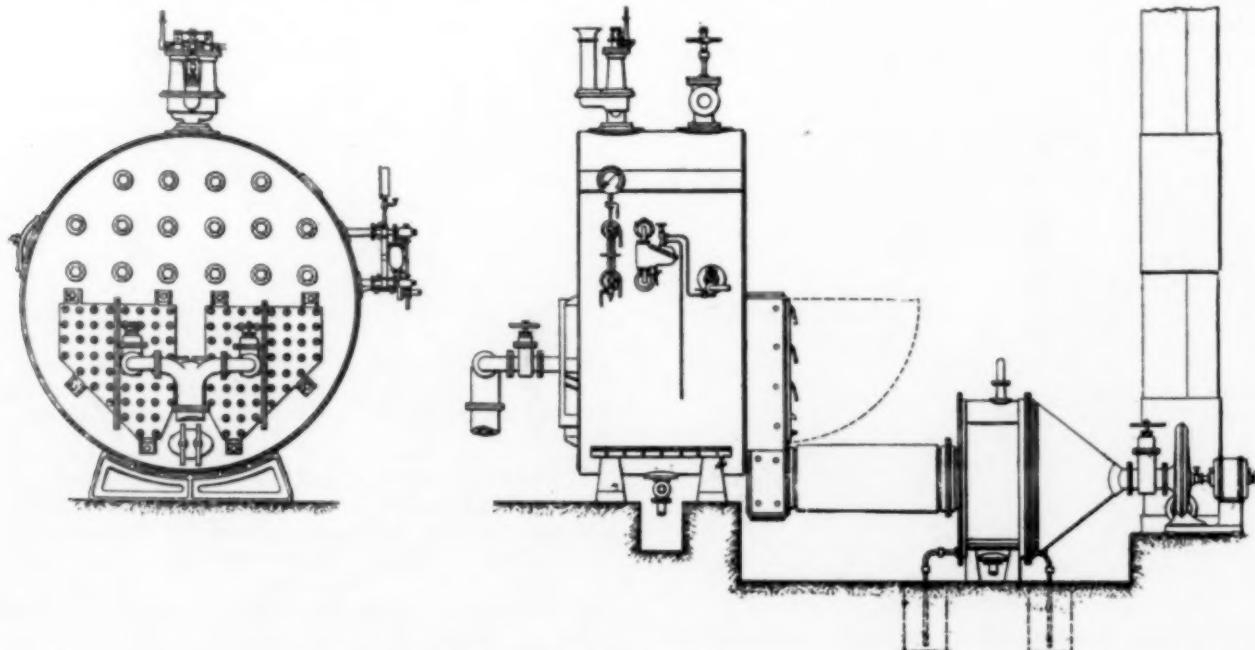
An important application of the principle to a large muffle furnace was, Prof. Bone said, illustrated in Fig. 1. The muffle in question measured 8 ft. x 3 ft. x 3 ft. internal dimensions. The gas and air were fed in at the front to a bed of granular material. On escaping from the top of the furnace the products of combustion were led down through a second bed of refractory fragments, embedded in which was the pipe furnish-

surface-combustion furnace without this regenerator required 50 cu. ft. of gas per hour, with the regenerator in use 37 cu. ft. to 40 cu. ft. of gas would suffice. Further, this regenerator made it possible to reach temperatures with "poor" gas which were otherwise only attainable with gas of high calorific value.

An important adaptation of the system, he continued, was to boiler firing. Gas-fired boilers had hitherto been far more satisfactory. The efficiency of a good water-tube boiler thus fired did not, he was informed, exceed 55 per cent or so, and in some experiments made with Lancashire boilers, similarly operated, the thermal efficiency did not exceed 60 per cent, although economizers were fitted. A small experimental boiler, arranged to work with surface combustion (as illustrated in Fig. 4 of our December issue, 1911, vol. IX, p. 629) was a cylindrical boiler, 3 ft. in diameter by 3 ft. long, traversed by ten horizontal tubes, 3 in. in diameter. These tubes were fitted at the inlet ends with a plug of fireclay, this plug having a 3-in. hole through the center, through which the explosive mixture was forced at a speed which prohibited the possibility of back-firing. The remainder of the tubes was packed with refractory material, on which the surface combustion was effected. The air supply was very little in excess of the theoretical requirements, but the combustion was absolutely completed within a distance of about 6 in. from the point of entry. The remainder of the packing then served to baffle the flow.

Though the temperature of the material in the zone of combustion was very high, the boiler tubes there never attained a red heat. The supply of gas to the tubes was at the rate of 100 cu. ft. of coal-gas per hour, or an equivalent amount of a power gas. A ten-tube boiler therefore took 1000 cu. ft. of gas per hour and 5000 to 6000 cu. ft. of air. The temperature of the escaping gases was never more than some 70 deg. C. above the temperature of the water in the boiler, and this was further reduced by passing them through a feed-heater consisting of water-tubes immersed in a bed of refractory material. From this the products of combustion escaped at a temperature of less than 100 deg. C.

On a test of this boiler the air and gas pressure was, he stated, 17.3 in. water-gauge, the drop of pressure being about 15 in. in the boiler and 2 in. in the feed-heater. The steam



FIGS. 2 AND 3.—BOILER FOR SURFACE COMBUSTION.

ing the supply of air, which was thus preheated to a temperature of 300 deg. to 500 deg. C. This resulted in a saving of 20 to 25 per cent. of the already low gas consumption. Thus if a

pressure was 100 lb. per square inch, corresponding to a temperature of 168 deg. C. The products of combustion left the boiler at a temperature of 230 deg. C., and the feed-heater at a

temperature of 95 deg. C. The total gas supply was 996 cu. ft. per hour, the calorific value being 562 B.t.u. per cu. ft., so that the 559,800 b.t.u. were supplied per hour. The actual evaporation was 450.3 lb. per hour, equivalent to 50 lb. evaporated from and at 212 deg. F. The heat transferred to the water was thus 527,800 b.t.u., so that the efficiency was 0.943. The carbon-dioxide in the escaping gases was 10.6, as against a theoretical value of 11, and the free oxygen was only 1.6 per cent. The rate of evaporation was 21.6 lb. per square foot, or double that of a locomotive.

Since last November a 110-tube boiler had, the lecturer said, been at work with coke-oven gas at the Skinningrove Iron Works, Cleveland. The boiler was built to the designs of Mr. Michael Longridge, by Messrs. Richardson, Westgarth and Company, Limited. This boiler is illustrated in Figs. 2 and 3. The drum is 10 ft. in diameter and 4 ft. long from back to front. It is traversed by 110 tubes 3 in. in diameter, packed, as already explained, with fragments of firebrick. The draught required is supplied by a suction fan, behind the feed-heater, giving a 20-in. water gauge. On test the mean evaporation was 20 lb. per square foot, but of this 70 per cent was effected in the first part of the length of the tubes, and 22 per cent over the next third. This steep temperature gradient along the tubes prevented circulation. Experience, Professor Bone stated, had further shown that scale would not adhere to the tubes. Once

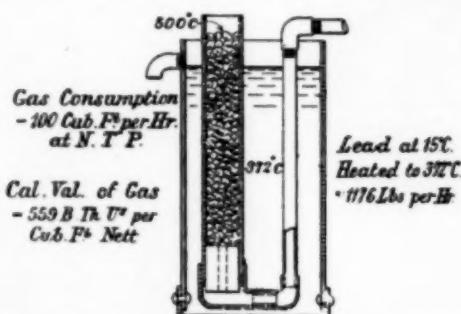


FIG. 4.—SURFACE-COMBUSTION APPARATUS FOR MELTING LEAD.

the thickness became about 1-32 in., it scaled off, falling down to the bottom.

Another application of the system was to the melting of readily fusible metals. One of the London newspapers required to keep 20 tons of type metal molten for 16 hours out of the 24. Coal-firing was inconvenient for this purpose, and gas-firing had hitherto been costly. The apparatus they proposed to use is illustrated in Fig. 3. It consists of an iron tank lagged outside with asbestos, while inside is a 3-in. tube stopped at the bottom with a fireclay plug on which rests the column of refractory material. A  $\frac{1}{4}$ -in. hole in the plug admits the supply of gas and air, which is fed in through the down tube on the right. In a test of the apparatus lead was melted at the rate of 1176 lb. per hour, the gas consumption being 100 cu. ft. "The efficiency worked out at 0.686 per cent. The gas left at only 130 deg. above the temperature of the lead, and if it were assumed that the temperature of the latter was a limit to that of the escaping gases, the efficiency was really greater than was represented by 0.686 per cent, being actually about 80 per cent of what was theoretically possible."

The General Bakelite Company has brought suits for infringements of its bakelite patents against the Condensite Company, of America and several users of "Condensite"; among them the Dickinson Manufacturing Company, of Springfield, Mass., the Duranoid Manufacturing Company, of Newark, N. J. and Hardman & Wright, of Belleville, N. J. In relation to this, it is of interest to note that the fundamental bakelite patents have been allowed in Germany and have been sustained by the German Patent Office, notwithstanding the fact of several public contestations.

## A New Method of Dressing Cornish Tin Ores.

BY MARCUS RUTHENBURG.

The complex tin ores of Cornwall have for many years been dressed for tin, the methods employed giving rise to the so-called Cornish system of tin dressing. Although the methods

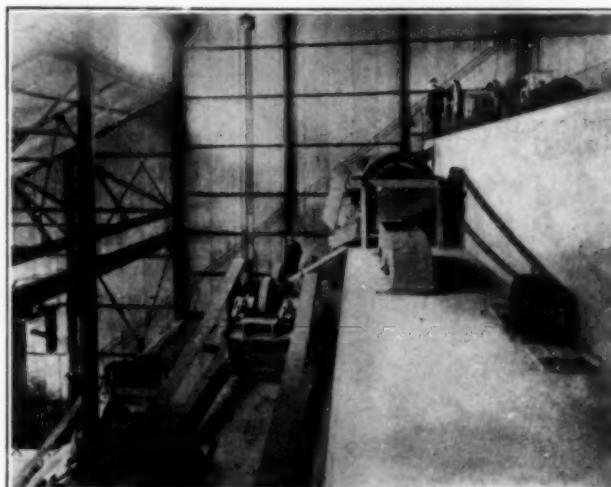


FIG. 1.—VIEW FROM UPPER END OF MILL, SHOWING CRUSHER, FIRST SCREEN, COARSE ROLLS AND SECOND SCREEN.

are crude they are adhered to tenaciously, and the average Cornishman is so wedded to these primitive processes as to be fully convinced that there is nothing in the world equal to them. They are like his Cornish pump, about which he is ready for an argument on the least provocation.

### Cornish Practice.

The accompanying photographs show the construction of a mill which is a radical departure from the Cornish methods of dressing tin ores. Before proceeding to a description of it, however, it may be of advantage to outline briefly the Cornish method, so that a comparison between the old and the new can be better understood. In the old process, the ore is crushed in a stamp battery. The more up-to-date of these machines are

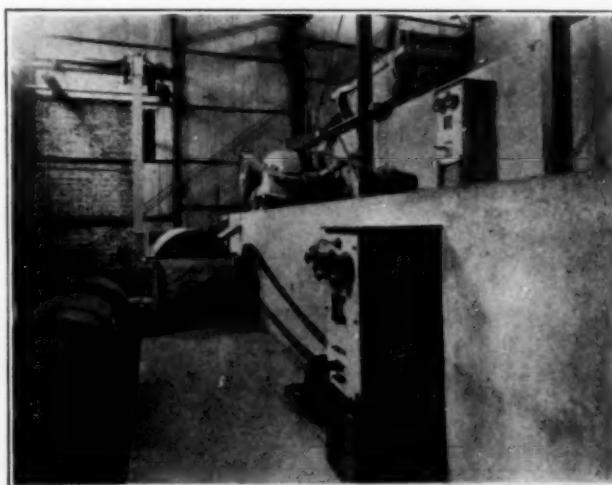


FIG. 2.—VIEW BELOW FIG. 1 SHOWING SECOND SCREEN, FINE ROLLS AND REVOLVING ROASTER.

of the California type or the pneumatic type. The crushed pulp is run to concentrating tables of different types, the Wilfley being largely used. The rough concentrates from these tables, containing all of the complex mineral in the ore—tin, copper, wolfram and manganite—are known locally as whits. The

whitts are roasted to eliminate arsenic and sulphur, the former being condensed in suitable chambers. Incident to the roasting operation, the iron particles become changed to oxide, and each grain swells and puffs out like a miniature cauliflower head,

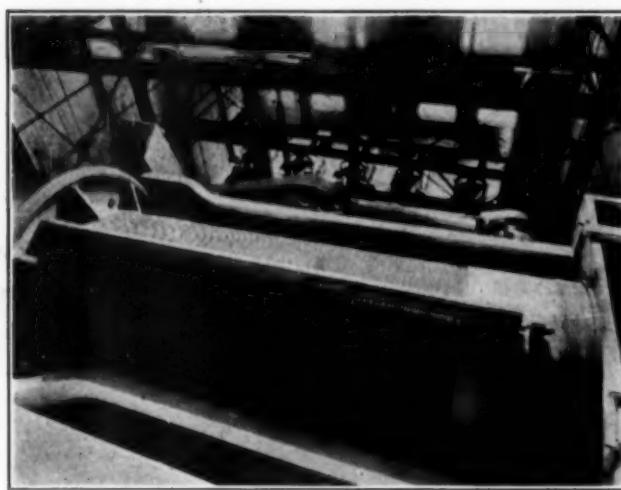


FIG. 3.—A CLOSE VIEW OF FIRST SCREEN—A REVOLVING GRIZZLY.

with consequent reduction in specific gravity. In the second concentration to which the roasted product is subjected, the iron is more easily separated from the cassiterite. Any copper in the whitts has been rendered soluble in the roasting operation, and is washed out. Frequently this wash water is run over scrap iron, and a part of the copper recovered as cement. In the fine crushing required to liberate the crystals of the various minerals, much of the tin is slimed, and good Cornish practice does not recover over 65 per cent of this metal.

*Latest Improved Practice.*

The above condition of affairs has led to a large amount of research, and the plant shown in the accompanying illustrations is the result of extensive investigation in the dressing of these ores. In this plant the ore is crushed to about 1-in. size in an ordinary rock breaker (see Fig. 1), which is followed by a 30-mesh screen. About 15 per cent of the crushed ore is

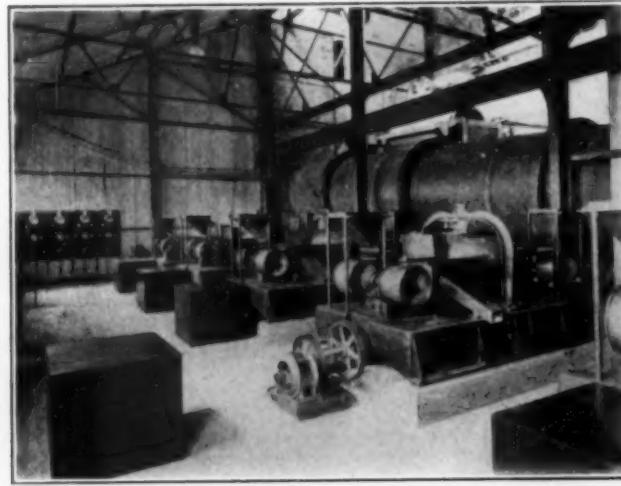


FIG. 4.—VIEW OF ROASTER AND MAGNETIC SEPARATORS.

fine enough to pass this screen, and is immediately removed from the crushing system, thereby avoiding excessive sliming and the rehandling of this quantity of ore. The oversize from the screen is fed to a pair of high-speed heavy steel rolls, 44 in. in diameter with a 6-in. face, set  $\frac{1}{4}$ -in. apart, and running at 200 r.p.m. This machine handles 10 tons per hour. Its product passes to a second 30-mesh screen where about 45 per

cent of the feed is removed as undersize. The oversize is reground in a second set of rolls of the same type as described. These rolls are set close, and reduce the entire feed to 30 mesh. This part of the plant is shown in Fig. 2.

The various screen products are combined and fed to a gas-fired roaster, where the iron contents of the ore are rendered magnetic in a "flash" roast. The cooled, roasted ore is then treated in magnetic separators, or more properly speaking, magnetic concentrators, inasmuch as it is the raw ore that is fed to them, and not an intermediate product from some previous operation of dressing. Everything that has the least trace of iron or wolfram in it is removed in these machines. The arrangement of the roaster and magnetic machines is shown in Figs. 4 and 5.

The tailing from the magnetic concentration is quartz and free cassiterite, the latter representing about half the tin in the original ore. This product is dressed on bubbles which produce a clean tin concentrate.

The concentrate from the magnetic machines contains everything of value except about half the tin, as noted, and consists of iron, tin, copper and wolfram. This product is further treated in magnetic separators, using different magnet strengths, whereby the most strongly magnetic material is removed first and the most weakly magnetic material last. This removes

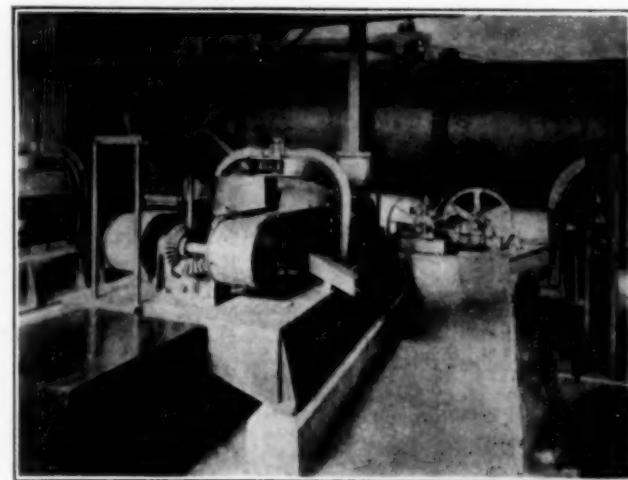


FIG. 5.—CLOSER VIEW OF MAGNETIC SEPARATORS.

the iron and wolfram as separate products, and leaves a mixture of tin and copper. This is roasted to remove arsenic, and then smelted to produce an alloy of tin and copper, which properly may be called a virgin bronze.

In this treatment of the mixed tin and copper, all of the cost of separation and the attendant loss of each metal are avoided. A large proportion of the tin and copper of the world's markets are combined into alloys of these metals by the founders. It seems, therefore, to be the height of folly to throw away a large proportion of the economic metals occurring in these ores merely for the purpose of effecting their separation, especially when they are again recombined by the founder in making his alloys. It has been the object of this work, therefore, to make large savings of the metals by never separating them, and carrying the smelting out in such a manner as to produce a finished alloy acceptable to commerce. By this method of working, the recovery rises from 65 per cent to 95 per cent.

*Details of Individual Machines.*

It may be well to describe the individual units of the plant in the order of their use. The screens must handle a large tonnage of coarse, heavy material, and yet remove only the part which is fine enough to pass a 30-mesh screen. To meet these conditions they were designed in the form of what may be called a ring grizzly, as shown in Fig. 3. The component parts are hard steel rings of V cross section, with the apex

of the **V** on the outside. The rings are assembled in a frame with distance pieces between them, and thus form a revolving grizzly giving a 30-mesh undersize. These screens handle a large tonnage of coarse material, removing the fine, with practically no wear.

The rolls also are worthy of attention. They are of the high-speed, narrow-tread type, with heavy steel shafts running in self-oiling, reversible bearings. The main feature of the rolls, however, is the device for keeping the faces true. Such rolls, if not kept absolutely true, are a source of great annoyance and do very poor work. At each end of the machine is a table, planed true with each roll shaft. On this table is a motor-driven emery wheel, which, vibrating with the roll (if at all), keeps it ground true. The bearings are self-oiling, with large oil cellars and dust covers. All of the machines have indi-

### Electric Furnace Pig Iron at Trollhättan

The Trollhättan furnace of the Jernkontoret of Sweden has now been operating over eighteen months. At the end of six months' work, Mr. Leffler gave to the Jernkontoret his monumental report on the working of the furnace—a report which has been widely reproduced in technical literature. (See this journal, vol. IX, 1911, pages 368, 459, 505.)

After nearly a year of further experience, J. A. LEFFLER and Engineer E. Nyström contributed to the meeting of the Jernkontoret in Stockholm, on May 31, 1912, a supplementary report of ninety-eight pages which is quite as complete and even more interesting than the original report, for it gives the full details of rapid progress in industrial efficiency. It covers the

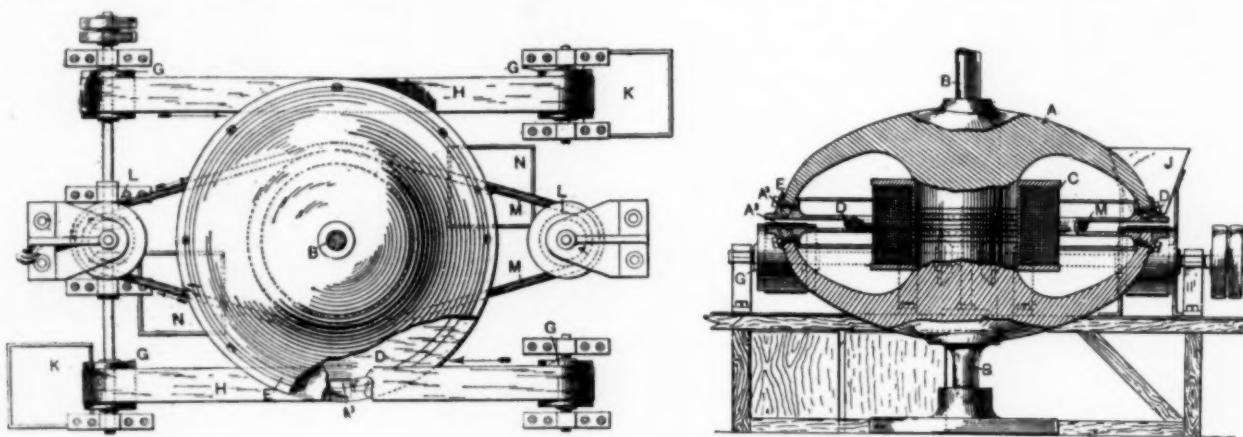


FIG. 6—DETAILS OF RUTHENBURG MAGNETIC SEPARATOR

vidual motor drive, two motors usually being run in opposite directions on each roll to avoid crossed belts.

The crushing and grinding plant here described handles 10 tons per hour, with a power consumption of 60 kw. A plant working on the same rock, and using forty California stamps of 1050 lb. each, grinding 5 tons per hour, consumed 86 kw. This gives a fair comparison between the two methods of crushing.

Details of the Ruthenburg magnetic separators are shown in Fig. 6. The double mushroom magnet *A* is mounted on a vertical spindle *B* which runs in suitable bearings. The central core is shown surrounded by the exciting coil *C*. The magnetic field is concentrated at the peripheral gap between the upper pole-piece *A'* and the lower pole-piece *A''*. A channel *D* of non-magnetic material is secured by flanges to the inside of the pole-pieces, and annular brackets *E* of the same substance are bolted to the outside. Pulleys *G* carry belts *H* which convey the crushed material between the pole-pieces where the magnetic particles are attracted and held to the upper pole-piece from which they are later removed by the rope *M* which runs in the non-magnetic channel *D*. The magnetic particles thus removed from the mass of ore are discharged into a receptacle *N*, while the balance of the non-magnetic material is carried on the belts *H* to receptacles *K*.

This plant was built by the Brush Electrical Engineering Company, London, and is an example of their work in metallurgical engineering. Their works at Loughborough and their agents in different parts of the world are prepared to undertake complete metallurgical investigations and the supply of proper equipment.

London, England.

The Nelson Valve Company of Chestnut Hill, Philadelphia, Pa., have recently published their illustrated catalogue on Nelson steel valves and fittings. Their prominent feature is that they are all made of acid open-hearth steel.

working of the furnace from August 4, 1911, to March 6, 1912.

During the summer of 1911 the furnace was closed down for alterations and repairs costing \$15,000. The four square electrodes were exchanged for six round ones, and a new gas-circulation system was installed for the better drying of the gas returned to the furnace. Figure 1 shows the gas-circulating system now used, consisting of a dust-catcher, cooler and powerful blower. The cooler acts on the condenser system, and requires 100 litres of water per minute to reduce the temperature of the gas so that its moisture content is reduced from 4 grams per cubic meter to 0.5 gram. All the electric pig-iron furnaces now being built and operated in Sweden and Norway are provided with this condenser, in order to avoid returning moisture to the smelting zone of the furnace.

**Fuel.**—Samples were taken every day of the 215 days run, of the fuel—charcoal from Norrland, Smoland, West Gothland and Vansbro, and 206 analyses are given, for water, gases, carbon and ash, the analyses being also calculated to dry fuel. The average analysis was:

Water	13.21	per cent
Volatile matter	11.72	"
Carbon	72.89	"
Ash	2.18	"
	100.00	"

**Limestone.**—The flux used was from Gasgrufvan, was charged unburnt, and contained:

Lime	54.32	per cent
Magnesia	0.31	"
Silica	1.68	"
Ferric oxide	0.24	"
Manganese oxide	0.35	"
Sulphur	0.001	"
Loss on ignition	42.94	"
	99.841	"

*Ores.*—Various hematites and magnetites were used, also slimed ore, briquettes and roasted ores. Analyses of thirty-eight different shipments are given, showing the following limits of composition:

Iron .....	42.02	to	68.95	per cent
Silica .....	3.42	"	28.46	"
Sulphur .....	0.001	"	0.138	"
Phosphorus .....	0.002	"	0.055	"

*Electrodes.*—The round forms were used, screwed into each other so as to avoid butt-ends. The dimensions were at first 550 mm diameter by 1500 mm long (22 x 60 in.), and later 600 mm diameter by 1800 long (24 x 72 in.). Figures 2 and 3 show two which run well; fig. 4 two which were irregularly consumed by currents of gas in the furnace. For the 215 days running, the average net consumption was 5.18 kg per ton of pig iron produced = 0.518 per cent of the weight of the iron. Mr. Leffler thinks it probable that pig iron can be made with less than 4 kg consumption. The smaller electrodes were from the Planiawerke at Ratibor, the larger from Siemens Bros. &

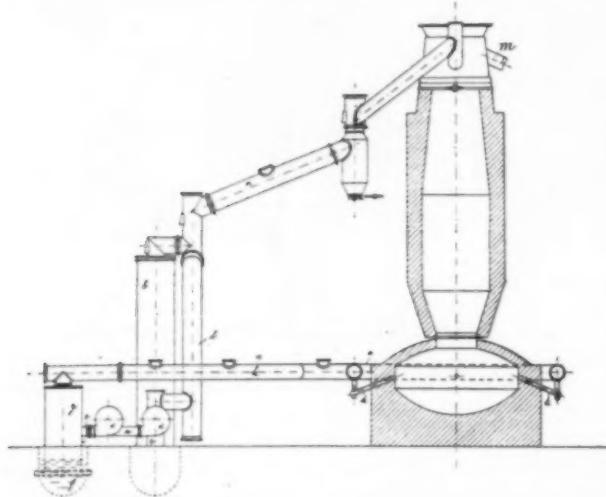


FIG. 1—ENTIRE GAS CIRCULATION APPARATUS

Co., Lichtenberg, near Berlin. The average composition was:

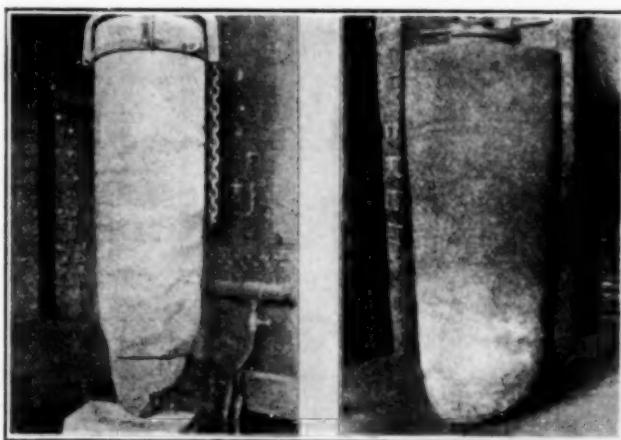
	Electrode per cent.	Electrode Connector per cent.
Ash .....	4.15	3.72
Phosphorus .....	0.022	0.011
Sulphur .....	0.85	0.80

The ash contained:

SO <sup>2</sup> .....	1.37	1.17
P <sup>2</sup> O <sup>5</sup> .....	1.23	0.64
SiO <sup>2</sup> .....	44.70	38.88
K <sup>2</sup> O + Na <sup>2</sup> O .....	1.62	1.06
CaO .....	6.04	5.52
MgO .....	1.92	2.65
Fe <sup>2</sup> O <sup>3</sup> .....	14.79	30.14
MnO <sup>2</sup> .....	0.52	0.44
Al <sup>2</sup> O <sup>3</sup> .....	27.73	18.12
	99.92	98.62

*Starting Furnace.*—Half a ton of scrap iron and half a ton of limestone was put on the hearth; on this was placed one ton of dry coke; over this a mixture of 3 tons of castings, 1.2 tons of coke and 0.18 tons of limestone. This filled the crucible up to the electrodes. Four-tenths ton of broken electrodes were then scattered on top, to give electrical connection between the electrodes. On top of this were placed regular charges of ore, fuel and limestone.

*Running.*—The furnace was run 28 days on Tuolluvaara ore, mixed with a little from Striberg (Karrgrufvan) and Ställ-



FIGS. 2 AND 3—ELECTRODES NORMALLY CONSUMED

berg (Kejsarschaktet); 35 days on a mixture of Tuolluvaara and Klacka-herberg fines; 14 days on a mixture of Norberg (Orling) ore and Mossgrafvet briquettes; 6 days on a mixture of Nyberg ore and Strassa briquettes; 5 days on Tuolluvaara, Persberg and Finnmosse ore and fines; 22 days on roasted

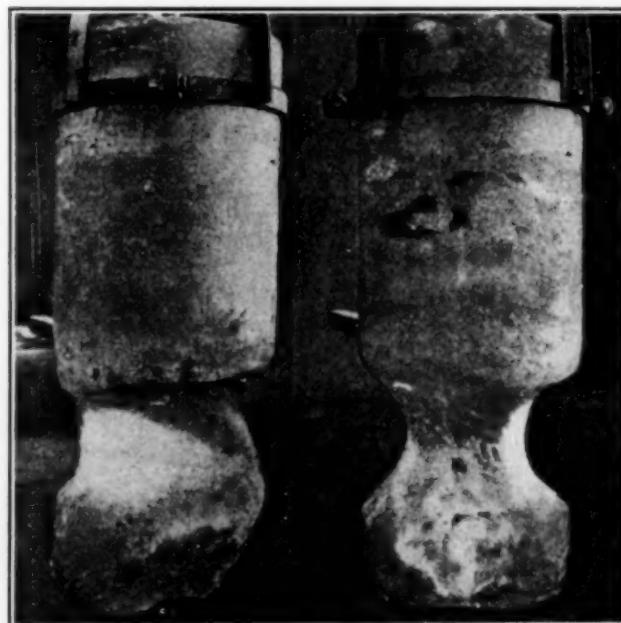


FIG. 4—ELECTRODES IRREGULARLY CONSUMED.

Tuolluvaara, Persberg and Finnmosse ores and unroasted Persberg fines; 10 days on the same, except the Persberg fines were also roasted; 13 days on a mixture of N. Stallberg (Kronprinzgrufvan), Norberg (Orling and Kolingberg), Grangärde (Björnberg, Långgrufvan), and Västra Ormberg (Pickgrufvan) ores, with Flogberg briquettes; 17 days on N. Stallberg, Norberg and Bispberg ores with Flogberg briquettes; and 10 days on Dannemora ores alone, mostly middle bed (85

parts) with some south bed (10 parts) and less north bed (5 parts).

*Charges.*—In the 215 days there was put into the furnace in regular running:

Iron Ore	5274 tons (metric. of 2204 lb.)
Limestone	381 "
Coal	1301 "

*Output:*

Pig iron	3215 "
Slag	1039 "

*Details of Running.*—The following are average figures summarizing the contents of two large tables giving the detailed running for the whole period:

Iron in ore	60.95 per cent
" burden	56.84 per cent
Weight of slag per ton of iron	323 kilos
" fuel	404 kilos
Volts on furnace	73.6 volts
Amperes on furnace	11,423 amp
Power on furnace	1482 kw
Power per ton of iron	2225 kw-hours
Output of iron per kw-year	3.94 tons
Per cent $\text{CO}_2$ in throat gas	23.49 per cent
Volume circulating gas, per sec.	0.24 cu. meter
Pressure of gas in furnace	225 mm $\text{H}_2\text{O}$ .
Temperature at bottom of shaft	441° C.
" middle "	279° C.
" top "	17° C.

*Electrode consumption, per ton of iron:*

Gross	5.72 kg
Net	5.18 kg

We cannot refrain, however, from considering the several stages of the run, as far as concerns the richness of the charge, amount of slag, output and power consumption. These figures are very instructive, because they show so clearly the dependence of cheap running on richness of the ore:

Per cent Fe in ore	67.66	66.71	57.15	54.83
Slag (kg) per ton iron	166	209	400	521
Coal (kg) per ton iron	347	380	439	490
Kw-hours per ton iron	1819	2253	2369	2525

The composition of the pig iron produced varied between the following limits:

Carbon	2.688 to 3.859	Average	3.406
Silicon	0.183 to 2.473	"	0.725
Manganese	0.190 to 1.366	"	0.477
Sulphur	0.0037 to 0.0341	"	0.0126
Phosphorus	0.0134 to 0.0454	"	0.0200

The composition of the gases produced varied as follows:

$\text{CO}^2$	14.63 to 31.80	Average	23.40
CO	31.80 to 71.10	"	63.15
$\text{H}_2$	7.87 to 14.50	"	10.35
$\text{CH}_4$	0.82 to 2.37	"	1.52
$\text{N}_2$ (difference)	0.50 to 3.41	"	1.49

The ratio  $\text{CO}/\text{CO}_2$  by volume was 4.8 at the worst and 1.8 at the best. The calorific power of the gas per cubic meter varied from 2035 to 2569, average 2297 Calories.

*Slags.*—The slags produced varied from 2.09 to 1.23 silicates (silica ratio). Analysis showed:

$\text{SiO}_2$	36.54 to 45.15	per cent
$\text{Al}_2\text{O}_3$	1.96 to 9.20	"
$\text{TiO}_2$	trace to 7.42	"
$\text{FeO}$	0.58 to 6.22	"
$\text{MnO}$	0.19 to 6.00	"
$\text{CaO}$	21.08 to 45.58	"
$\text{MgO}$	6.22 to 26.65	"
$\text{CaS}$	0.04 to 0.44	"
$\text{P}_2\text{O}_5$	trace to 0.034	"

*Temperatures.*—The temperatures of iron and slag issuing from the furnace varied as follows:

Iron	1230° to 1420° C.
Slag	1290° to 1460° C.

A large table gives the temperatures taken at 8 points in the shaft, just inside the wall and in the middle; also the percentages of  $\text{CO}_2$  in the gases at these different points.

There are various not very important irregularities in the figures, but the general average shows temperatures up to 985 deg. in the middle at the lower part of the shaft and 585 deg. half way up; while near the wall it is 420 deg. to 565 deg. at the lowest hole and down to 15 deg. at the highest.

The measured percentage of  $\text{CO}_2$  shows that reduction takes place ordinarily only one-quarter way up the shaft at the sides and a little over one-half way up in the center.

The extent of the zone of reduction by  $\text{CO}$  is clearly shown in Fig. 5, in which also some temperatures are indicated.

*Cooling Water.*—The contacts and jackets through which the electrodes worked were water cooled. The heat carried away thus varied from 172 to 288 kw, or 10.47 to 19.30 (average 14.50) per cent of the power used.

*Thermal Balance.*—The heat balance per 1000 kg of pig iron is worked out for the four weeks Sept. 3 to Oct. 1, 1911, in which the average power used (high tension side) was 1407 kw, and the power consumption 1749 kw hours per ton of pig iron; the ores worked were the rich Tuolluvaara ores. The heat balance is, per kg of iron:

Combustion C to $\text{CO}_2$	567 Calories
Combustion C to CO	381 "
Electric energy	1504 "

2452 Calories

Consumed in reductions	1620 Calories
Decomposition of limestone	35 "
Evaporation of water	24 "
Sensible heat in throat gases	26 "
Sensible heat in slag	75 "
Sensible heat in pig iron	300 "
Cooling water	195 "
Lost in transformers	43 "
Lost in conductors	44 "
Radiation and conduction	90 "

2452 Calories

The authors then make some interesting calculations, the results of which are, in brief, as follows: The gas kept in circulation was 2.28 times the gas normally produced and escaping. Assuming this gas to enter the furnace at 22° and to enter the shaft at 1000°, it carried into the shaft as sensible heat 343,118 calories per ton of iron, or 22.9 per cent of all the heat electrically generated in the crucible. Since it carried with it 22.5 kg. of water vapor and 174 kg. of  $\text{CO}_2$ , both of which are decomposed by the glowing carbon, the net heat absorbed in these decompositions is 160,283 calories, or 10.7 per cent of the electric energy used. The gas circulation therefore transferred physically and chemically 33.6 per cent = 1/3 of the electrical

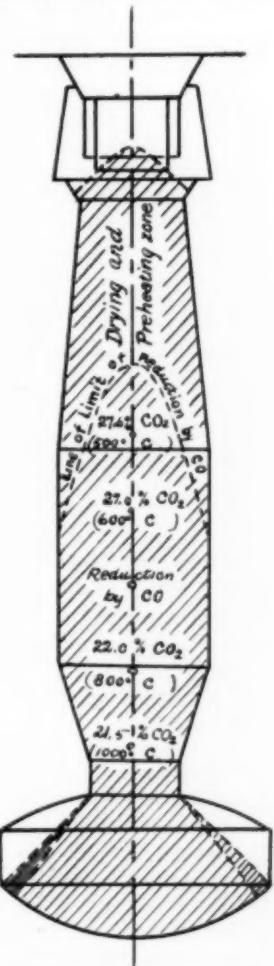


FIG. 5.—TEMPERATURE AND REACTION IN FURNACE SHAFT

energy used from the crucible into the shaft of the furnace. [We cannot refrain from asking what would result from simply generating in the shaft  $1/3$  of the total electrical energy and  $2/3$  in the crucible. Would not that simple partition of the current effect quantitatively exactly the same distribution of heat as is now obtained by circulating the gases? Would not that, if practicable, obviate the necessity of circulating the gases in order to carry heat up into the shaft?—Translator.]

As a whole, the working of the furnace these seven months may be designated as satisfactory but not satisfying; the system of gas circulation with its limitation on the economy of fuel gives a temporary advantage but sets a sharp limit on future reduction of fuel consumption; the possibilities of very low carbon product—pig steel—have not been tried out; the lower limits of power consumption have not been determined; in short, the whole question still remains in an interesting condition, with the possibilities of the future large and attractive.

### Calibration of Radiation Pyrometers.

By G. A. SHOOK.

#### Black Body Standards.

In order to calibrate or standardize a pyrometer it is necessary to have a luminous source whose black body temperature is accurately known. The primary standard must be some form of a heated inclosure whose walls can be maintained at a uniform constant temperature. Some means must also be used for determining the true temperature of the inside of the inclosure.

This is generally accomplished by some form of an electric resistance furnace, as shown in Fig. 1. It consists of a central porcelain tube overwound with thin platinum foil through which passes an electric current which can be adjusted to maintain any desired temperature up to about 1600 deg. C. Concentric with this tube are two shorter ones which, with the intervening air spaces, minimize the radiation. Some form of thermo-couple is placed in one end so that the hot junction is near the center of the tube. If there is a cold junction it should be placed in crushed ice.

The thermo-couple may be either connected to a potentiometer or a sensitive potential galvanometer which reads

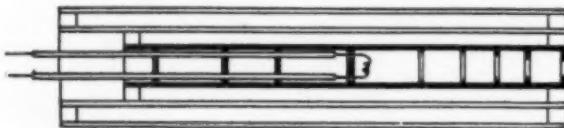


FIG. 1—ELECTRIC RESISTANCE FURNACE FOR PYROMETER CALIBRATION.

millivolts, and by means of previously determined calibration any temperature may be determined. Except in refined work the ice point is not necessary. The furnace is connected in series with a rheostat and a 110-volt direct-current circuit.

For the calibration of the Wanner or Le Chatelier pyrometer it is necessary, as will be shown later on, to know but one black-body temperature so that as a working standard any convenient luminous object, such as a frosted-globe incandescent lamp, which would give a uniformly illuminated area of about 1 sq. cm., might be used, if its black-body temperature at some particular current strength were accurately known.

For pyrometers like the Holburn-Kurlbaum (H.-K.), however, which can only be calibrated empirically, it is necessary to have a black-body whose temperature can be varied. This is generally done by means of an electric furnace, but when a Wanner, Le Chatelier or a calibrated H.-K. is at hand it is most easily accomplished by direct comparison.

The comparison source may be a thin platinum strip, heated electrically or a wide-filament incandescent lamp. The H.-K. pyrometer may be sighted on one side of the strip and the

calibrated pyrometer on the opposite side. The black-body temperature of the strip can be determined by means of the calibrated instrument and at the same time the reading of the H.-K. comparison lamp can be taken.

In the case of a wide-filament carbon incandescent lamp it has been shown that if it is properly aged for about twenty hours at 1700 deg. C., it will remain sufficiently permanent for a secondary standard for fifteen to twenty hours.

If such a lamp is calibrated in terms of black-body temperature and current strength, by means of a pyrometer, it may be used as a standard of comparison for calibrating pyrometers, just as a black-body would be used.

For industrial work, the "Pyrometer Comparison Lamp" i. e., the wide-filament incandescent lamp, is undoubtedly the best standard. It costs considerably less than any sort of a furnace and, being as stable as any incandescent lamp, it can be easily sent to the United States Bureau of Standards for calibration.

The following is a typical table furnished by the Bureau of Standards for a lamp used in the author's laboratory:

Current, Amperes.	Temperature, Centigrade.
3	710 deg.
4	865 deg.
5	985 deg.
6	1090 deg.
7	1190 deg.
8	1280 deg.
9	1365 deg.
10	1450 deg.

If one is constantly calibrating a large number of pyrometers, as is the case with the instrument maker, it is best to have on

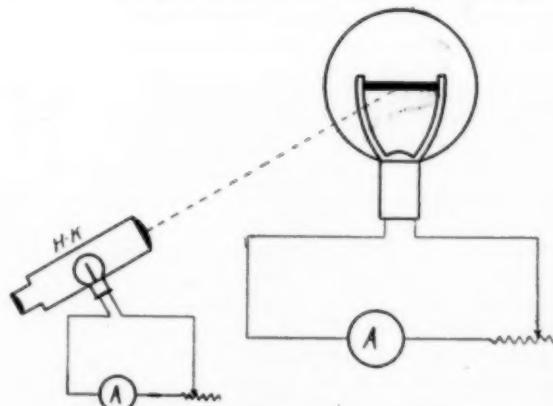


FIG. 2.—OUTFIT FOR CALIBRATING PYROMETERS.

hand five or six of such lamps and to keep in reserve the certified lamp as a primary standard. The others can be used directly as working standards, as they can all be readily calibrated by means of any calibrated pyrometer.

A complete calibrating outfit would consist of a 0-10 amp. ammeter, a suitable rheostat, and a calibrated lamp, Fig. 2.

Such a lamp would entirely do away with such a troublesome standard as the amyl acetate lamp. It should be borne in mind that no matter how carefully an instrument may be constructed or how carefully it may be calibrated, the accuracy of all subsequent measurements is subordinate to the accuracy to which the comparison lamp can be standardized. For all accurate work a standard as unreliable as the amyl acetate flame should not be depended upon.

#### Calibration of Total Radiation Pyrometers.

Since we are concerned here with the total radiation given out by an incandescent body, we must always use some sort of a furnace. The best method is to calibrate such a pyrometer empirically, point by point, and to mark the temperature upon

the scale of the galvanometer which is used in connection with the thermo-couple. Since glass does not transmit all of the spectrum of a black-body, any incandescent object enclosed by glass could not, of course, be used for calibrating total radiation pyrometers. For the same reason, in using a total radiation pyrometer, which has been calibrated against a black-body, the beam of light reaching the instrument should never be obstructed by a piece of glass.

In the case of pyrometers of the Féry and Thwing type as long as the thermo-couple remains intact and as long as the galvanometer is not injured in any way, such an instrument will require no recalibration.

With optical pyrometers, however, which use comparison lamps, the case is quite different and their calibration must be taken up more in detail.

#### Calibration of Optical Pyrometers.

It was shown in the first paper of this series that the black-body temperature (deg. C.) of any incandescent object, in terms of the photometric intensity, is given by the expression:

$$t = \frac{K_2}{K_1 - \log J} - 273 \quad (1)$$

$$K_1 = C_2 \frac{\log e}{\lambda}$$

and

$$K_1 = \log J + \frac{K_2}{T}$$

$$C_2 = \text{constant} = 14,500.$$

$$\log e = 0.4343.$$

$\lambda$  = wave length in  $\mu$ .

$t$  = temperature Centigrade.

$T$  = absolute temperature ( $t + 273$ ).

$J$  = luminous intensity.

The logarithm that is generally used is the *common* or Briggs, but the logarithm that appears in the equation is the *natural*. To distinguish the common log from the natural log the former is sometimes written  $\log_{10}$  and from the theory of logarithms  $\log J = \log e \times \log_{10} J$  or  $\log J = 0.4343 \times \log_{10} J$ .

The expression  $\log J$  is ordinarily taken, however to mean the *common logarithm of J*. In all the following equations the *log* that appears is the common logarithm and is identical with that obtained by means of the so-called *logarithmic tables* which may be found in any engineering handbook. The method of determining the logarithm of a number is generally given briefly in connection with most tables.

Equation (1) is sufficiently accurate for all temperatures up to about 3000 deg. C., but for temperatures of the magnitude of 6000 deg. C. it is better to use Planck's equation. This point, however, will be taken up again in a subsequent paper.

When  $\lambda$ , the wave-length of light used, is known  $K_1$  is determined and if  $J$  is known for a particular value of  $t$ ,  $K_1$  may be determined. Within certain limits, which are determined by the intensity of the comparison lamp,  $t$  can be arbitrarily chosen for a particular value of  $J$  or vice versa.

When  $K_1$  and  $K_2$  are known, a series of values of  $t$  can then be substituted in the "pyrometer equation" (equation (1)) and the corresponding values of  $J$  can be determined readily. Hence a complete calibration table can be accurately made without reference to any temperature observation whatever. This fact seems to have been entirely overlooked by most instrument makers.

Such a table containing the values of  $J$  and  $t$  will, of course, last indefinitely. While this method of calibration may require more time at the outset, it is believed by the author that it is well worth the time to make out a complete table by means of equation (1), rather than to use any of the graphical methods that are sometimes given.

Some time ago the writer worked out a direct-reading scale applicable to pyrometers of the Wanner type and since then direct-reading scales have been applied to the Wanner and to

the Scimato pyrometers. The theory of the Scimato is the same as that of the Wanner instrument, but the former has a number of improvements over the Wanner type.

The method of calibrating the different pyrometers may perhaps best be shown by means of examples. The general remarks made on the particular instruments will, of course, apply to any optical pyrometer in which the intensity can be varied in a continuous and determinate manner.

#### Calibration of Warmer Pyrometer.

In the Wanner pyrometer the relation between the luminous intensity and the angle through which the Nicol analyzer must be turned in order to produce a photometric balance is

$$J = \tan^2 \phi.$$

For a particular Wanner pyrometer the value of  $\lambda$  is  $0.656 \mu$ .

$$\text{Therefore } K_1 = \frac{C_2 \log e}{\lambda},$$

$$K_1 = \frac{14,500 \times 0.4343}{0.656}$$

$$K_1 = 9600.$$

Now suppose we have

$$T = 1273. \text{ deg. and } \phi = 45. \text{ deg.}$$

Then,

$$K_1 = \log \tan^2 \phi + K_2 \frac{1}{T}$$

$$= 0 + \frac{9600}{1273} = 7.55.$$

Therefore

$$t = \frac{9600}{7.55 - \log \tan^2 \phi} - 273 \quad (2)$$

or

$$= \frac{9600}{7.55 - 2 \log \tan \phi} - 273$$

A table may then be made out with the values of  $\phi$  and  $t$  for subsequent use.

If now the pyrometer be sighted upon any object whose black-body temperature is known, the Nicol may be set to correspond to this temperature and the current through the incandescent comparison lamp adjusted until a photometric balance is effected. The table made out will then hold for any unknown temperature given therein.

The angle for the calibration temperature must be chosen to suit the conditions under which the instrument is to be used, which are in turn limited by the intensity of the comparison lamp.

For instance, the Nicol analyzer turns through 90 deg., that is, from 0 to 90, but it is most sensitive in the neighborhood of 45 deg. since in this position the values of the tangent change less rapidly with a given change in angle. For high temperatures the analyzer must, of course, be turned through a greater angle than 45 deg. in order to produce equality of brightness, but the limit of accuracy is reached at about 80 deg., although theoretically intensities indefinitely high can be measured up to 90 deg.

Under these conditions the instrument cannot be used for temperatures much higher than about 1800 deg. since the lamp would have to be run at too high a degree of incandescence, which means short life and, therefore, recalibration. For measuring low temperatures, however, the limit is only reached by the loss of light, which makes a setting very difficult.

In the case of any pyrometer a few preliminary trials must be made in order to determine its range.

Table I was constructed as follows:

TABLE I.

$t$	$\phi$	$\log \tan^2 \phi - 10$
787	10	-1.51
864	20	-0.88
922	30	-0.48
972	40	-0.15

1026	50	+ 0.15
1084	60	+ 0.48
1165	70	+ 0.88
1315	80	+ 1.51

A series of values of  $\phi$  were put in the table, as shown, and then the corresponding values of the  $\log \tan^2 \phi$  were found from a table of trigonometric functions. For each value of  $\phi$  the corresponding value of  $t$  was then found from equation (2).

For  $\phi = 10$ ,  $\log \tan^2 \phi - 10 = -1.51$ .

Hence

$$t = \frac{9600}{7.55 + 1.51} - 273 \\ = 787^\circ \text{ C.}$$

For  $\phi = 60^\circ$ ,  $\log \tan^2 \phi - 10 = 0.48$ .

Therefore,

$$t = 1084^\circ \text{ C., etc., etc.}$$

#### Calibration of Le Chatelier Pyrometer.

The wave-length for the red glass used on a Le Chatelier pyrometer was found to be  $0.649\mu$ . The constant  $K_2$  then becomes

$$K_2 = \frac{14,500 \times 0.4343}{0.649} = 9700.$$

In this case  $J = \left(\frac{1}{s}\right)^2$ , where  $s$  is the length of one side

of the iris diaphragm. (See Fig. 8 in my article on page 337 of June issue.) In order to measure a very high temperature the diaphragm must be made small in order to obtain a photometric balance.  $s$  then becomes small and obviously  $J$  increases. Evidently an extremely high temperature could not be measured by simply making the diaphragm minutely small, for the error introduced in measuring such a small diaphragm would be large and, furthermore, there are optical difficulties that render the use of very small apertures impractical.

The upper limit of  $s$  is reached when the full aperture of the lens is used and that particular value of  $s$  corresponds to the lowest temperature that the instrument will measure without further modification.

For a particular instrument, it was found, by means of a few rough measurements, that a diaphragm reading of 24.2 corresponds to a temperature 1012 deg. C. Suppose we assume that  $s = 25$  when  $t = 1000$  deg. C. From a logarithmic table

$$\log (1/s)^2 = \log (1/25)^2 = -2.80.$$

Hence

$$K_1 = \log J + K_2/T \\ = \log \left(\frac{1}{s}\right)^2 + K_2/T \\ = -2.80 + 9700/1273 = 4.82.$$

Therefore

$$t = \frac{9700}{4.82 - \log (1/s)^2} - 273.$$

or

$$t = \frac{9700}{4.82 - 2 \log (1/s)} - 273 \quad (3)$$

Various values of  $s$  were substituted in equation (3) and the corresponding values of  $t$  calculated. Thus for  $s = 20$ ,

$$t = \frac{9700}{4.82 - 2 \log (1/20)} - 273 = 1033.$$

TABLE II.

$s$	$t$
25	1000
20	1033
15	1080
6	1247
4	1337
2	1513

To completely standardize this instrument it is only necessary to direct it toward some incandescent body whose black-body temperature is known. Suppose this temperature is 1247 deg. C., from Table II we see that this corresponds to a diaphragm have equal intensity. If a fiducial mark, such as a fine platinum wire, is made for the tip of the flame the latter can always be brought to the same intensity without the use of any auxiliary standard. If gasoline from the same can is always used the calibration will hold indefinitely.

If the instrument is used for different distances, it must be focalized each time. In this case the length of the draw-tube, containing the diaphragm, must be taken into account in the calculation of  $J$  and this makes the calibration rather complicated. It is not impossible, however, to always use the pyrometer at the same distance from the radiating body and if this distance does vary 50 cm or so the variation will not produce a sensible error in the value of the temperature.

#### Calibration of Holborn-Kurlbaum Pyrometer.

The H-K pyrometer is generally calibrated empirically by means of a number of black-body temperatures. Some form of an electric furnace is usually employed, but a pyrometer comparison lamp (Fig. 2) will do just as well. The pyrometer is directed toward the incandescent body in question and the

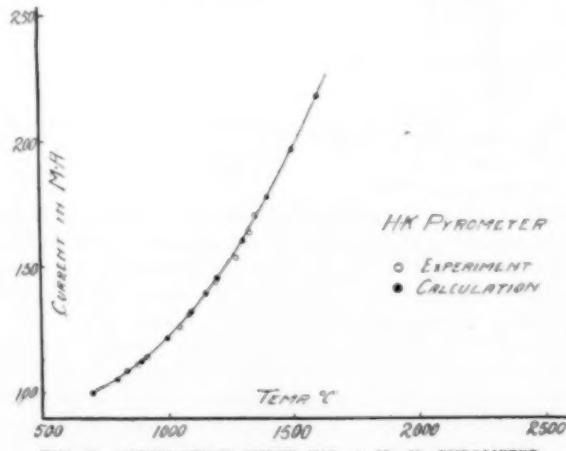


FIG. 3—CALIBRATION CURVE FOR A H. K. PYROMETER.

current through the H-K lamp is varied until the filament disappears against the bright background. A curve is then plotted co-ordinating black-body temperature (deg. C.) and current values (milliamperes).

It has been shown by experiment that the relation between the current through the comparison lamp and its black-body temperature can be expressed sufficiently well by a quadratic formula of the form

$$I = a + bt + ct^2. \quad (4)$$

where  $I$  is the current in milliamperes and  $a$ ,  $b$  and  $c$  are constants which can be determined if three temperatures are known.

This method is especially applicable when for any reason the temperature range used for calibration is limited, for instance, when comparison is made by means of a platinum strip whose temperature is measured by means of a Wanner pyrometer. The Wanner will not read accurately much lower than 900 deg. C., while the lower limit of the H-K is about 600 deg. C.

When a number of points have been determined under such conditions, the best method is to draw a smooth curve through all the points and from the curve select three temperatures which will represent a good average and from these determine the constants of equation (4).

For example, the points marked  $o$  on the curve, Fig. 3, were determined by sighting the H-K pyrometer upon a platinum strip whose black-body temperature was determined by means

of a Wanner pyrometer. A smooth curve was drawn through these points and the following data taken from the curve:

Temperature, degrees C. ....	900	1100	1300
Current, milliamperes .....	112	132	160

Substituting these values in equation (4) three independent equations were obtained from which the general equation was determined.

$$I = 121 - 0.100 t + 0.000100 t^2. \quad (5)$$

Various values of  $t$  were then substituted in equation (5) and the corresponding values of  $I$  determined as in Table III.

TABLE III.

$I_0$ by experiment.		$I$ by calculation.	
$t_0$	$I_0$	$t$	$I$
838	100.0	500	96.0
882	111.0	600	97.0
...	...	...	...
1330	163.6	1500	196.0
1355	170.0	1600	217.0

A method for calibrating an H-K pyrometer by means of only one known temperature has been worked out by Mendenhall and may be applied as follows: Suppose we have but one known temperature, say the melting temperature of palladium,

FIG. 4.— $R = 360 \div 30 = 120$  AND  $R = 360 \div 50 = 7.2$ .

1549 deg. C., then by means of a number of rotating sector disks, having apertures of  $\frac{1}{2}$ ,  $\frac{1}{4}$ ,  $\frac{1}{10}$ ,  $\frac{1}{60}$ ,  $\frac{1}{120}$ , a range of temperatures can be obtained from about 1030 deg. to 1450 deg. If it is desired to construct a curve by means of equation (4) using three temperatures, then two disks will be sufficient. The melting point of palladium can be taken as one temperature and the two disks will give values corresponding to two more temperatures.

If a disk has a sector of 3 degrees, Fig. 4, then it only transmits  $\frac{1}{120}$  of the incident radiation. The incident intensity, then, is 120 times the intensity of the radiation transmitted; that is, it is 120 times the apparent intensity that would be indicated by a photometer.

Suppose the radiation incident upon the objective of an H-K pyrometer is cut down by means of a rotating disk. Let  $J'$  = intensity of the incident radiation.

$J$  = the value as indicated by the instrument, when the rotating sector is used.

Then

$$J' = JR \text{ or } R = J' \div J, \quad (6)$$

where  $R$  = absorption factor of the disk. Let  $T'$  represent the absolute temperature of the radiating body in question, in this case 1549 deg. + 273 deg., and let  $T$  represent the temperature as determined by the pyrometer when the absorption disk is used.

From (1)

$$\log J' = K_1 - K_2/T \quad (7)$$

and

$$J = K_1 - K_2/T \quad (8)$$

Subtracting (8) from (7)

$$\log (J'/J) = K_2(1/T - 1/T')$$

From (6)

$$\log J'/J = \log R$$

Therefore,

$$\log R = K_2(1/T - 1/T')$$

Whence

$$(\log R)/K_2 = K = 1/T - 1/T'$$

$$1/T = 1/T' + K \quad (9)$$

Equation (9) gives the apparent temperature of the palladium in terms of the actual temperature.

Since

$$T' = 1549 + 273 = 1822$$

$$1/T' = 0.00055$$

For a particular H-K instrument  $K_2 = 9700$  and for a 3-degree sector  $R = 120$ . Therefore,

$$K = (\log 120) \div 9700 = 2.079 \div 9700 = 0.000214$$

Hence

$$1/T = 0.00055 + 0.000214 = 0.000764$$

Therefore

$$T = 1303 \text{ and } t = 1030$$

In a similar manner for 50-deg. disk,  $t = 1290$ .

Therefore from one original known temperature we have derived three, namely, 1549, 1290, 1030, which may be used to construct a calibration curve.

These temperatures are, of course, the true or thermodynamic temperatures, and this means that the palladium must be brought to its melting point in a uniformly heated enclosure, such as an electric furnace.

In order to make a temperature observation the furnace is slowly heated up to the desired temperature at the rate of a few degrees a minute. The pyrometer may be sighted upon a central diaphragm of the furnace, near which is placed the specimen of palladium and the instant of melting is determined either directly by means of a microscope or by the interruption of an electric circuit. The palladium might be brought to its melting point by means of a surface radiator, but in this case the black-body temperature must be known.

Now while the black-body temperature of a radiating surface can be measured with considerable accuracy, the true temperature, at the instant of melting, is difficult to measure, due to the changes of the surface, such as oxidation and crystallization, etc. Hence, the relation between the two temperatures, at the melting point, is very uncertain. Furthermore, the black-body temperature, alone, is useless unless we know the wave-length at which the observation was determined.

The black-body temperature of the melting point of palladium for three different wave-lengths is as follows:

$$\text{Wave-length} \dots \dots \dots 0.662\mu \quad 0.547\mu \quad 0.462\mu$$

$$\text{Melting point} \dots \dots \dots 1386^\circ \quad 1425^\circ \quad 1450^\circ$$

If a thin platinum strip is bent into the form of a narrow wedge, Fig. 5, and heated to incandescence, the radiation from

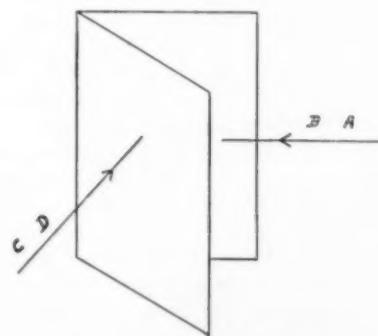


FIG. 5.—WEDGE-SHAPED CAVITY.

the interior will be observed to be quite different from the radiation emitted by the exterior surface. Hence if a temperature observation is made, by means of an H-K pyrometer, in the direction  $AB$  the pyrometer will indicate the true or thermodynamic temperature of the strip. However, when an observation is made in the direction  $CD$  the instrument then indicates the black-body temperature of the strip.

By means of such a wedge-shaped cavity the relation between the black-body and the true temperature of a metal can be experimentally determined. Such a wedge used in a hori-

zontal position may serve as a sensitive mordometer for the determination of melting points of salts between 700 deg. and 1600 deg. C.

Finally, any radiation pyrometer calibrated by means of known black-body temperatures indicates the black-body temperature of an incandescent object unless the object sighted upon is itself a black-body in which case it indicates the true or thermodynamic temperature.

When black-body conditions are not realized, as, for example, in the determination of the temperature of an incandescent sheet of metal, the temperature can only be expressed as black-body temperature unless we know the departure from black-body radiation for the particular metal.

Except in the case of a few metals, like platinum and palladium, very little is known at the present time concerning the departure from black-body radiation.

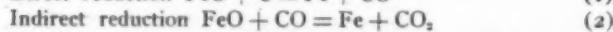
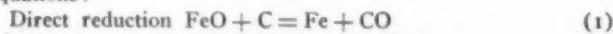
University of Illinois,  
Urbana, Ill.

### Direct and Indirect Reduction in the Blast Furnace\*

By M. LEVIN.

Direct reduction in a blast furnace may be defined as the reduction of the iron ore by the solid fuel, whereby the fuel is charged into CO, while indirect reduction is the reduction of the ore by CO which was previously produced by direct reduction, whereby the CO is changed into CO<sub>2</sub>. Since in the lower part of the blast furnace CO<sub>2</sub> cannot exist, only direct reduction will occur there so that indirect reduction is limited to the middle and upper parts of the furnace.

Assuming that the iron ore is FeO, we have the following equations:

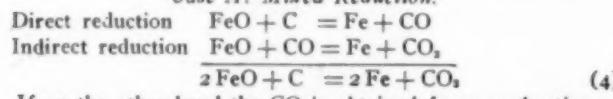


The reaction (1) of direct reduction can and does occur independently of all other reactions, while indirect reduction (2) is always dependent on the formation and presence of CO. Now the presence of CO may either be due to previous direct reduction (1) or to the combination of the fuel with atmospheric oxygen in the air blast:



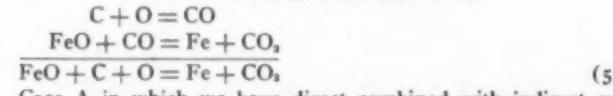
If CO formed by direct reduction is the reducing agent in the indirect reduction process we have the following equations:

Case A: Mixed Reduction.



If on the other hand the CO is obtained from combustion of fuel by the air blast, the equations are:

Case B: Pure Indirect Reduction.



Case A in which we have direct combined with indirect reduction may be called "mixed reduction," while in case "B" we have combustion without any direct reduction and we may speak in this case of "pure indirect reduction."

The amount of C consumed and the amount of CO<sub>2</sub> formed is the same in equations (4) and (5), but "mixed reduction" A yields twice the amount of Fe which is produced by "pure indirect reduction" B per unit of fuel.

It will now be shown that the analysis of blast furnace gases is a simple means of determining whether in a blast furnace pure indirect reaction takes place or not.

The air blast contains 26.5 volumes of oxygen (O<sub>2</sub>) per 100 volumes of nitrogen. The oxygen combines with carbon and forms fifty-three volumes of CO per 100 nitrogen.

\*Translated slightly in abstract, from *Metallurgie*, vol. 8, Oct. 8, 1911, p. 606.

In the lower part of the furnace this amount of CO, due to the air blast burning up carbon, may be increased by CO formed by direct reduction, while in the upper part of the furnace the amount of CO may be reduced in two ways, one of which is indirect reduction (2) and the other decomposition of CO by the reaction.



If we now assume that the N<sub>2</sub> from the air blast ascends through the furnace in unvarying quantity, it is obvious that a proportion of more than fifty-three volumes of CO per 100 volumes of N<sub>2</sub> proves that in the lower part of the furnace more CO has been formed by direct reduction (1) than has been consumed in the upper part by indirect reduction (2) or changed into C and CO<sub>2</sub> by the decomposition (6) of CO.

If the ratio of the volumes of CO to 100 N<sub>2</sub> is fifty-three, these reactions in the lower and upper parts of the furnace are in balance so that the same amount of CO leaves the furnace as has been formed by the burning of the fuel by the air blast.

In other words, if in the latter case indirect reduction (2) or decomposition (6) of CO has taken place, an amount of CO equal to that thus consumed must have been formed in the lower part by direct reduction (1).

We have therefore reached this result: *If in a blast furnace gas the CO content is greater than or equal to fifty-three volumes per 100 volumes of nitrogen, only direct or mixed reduction but not "pure indirect reduction" takes place in the whole furnace.* If the amount of CO is below fifty-three volumes per 100 volumes N<sub>2</sub>, more CO is being consumed in the upper part of the furnace than was formed in the lower part by direct reduction and this consumption of CO in the upper part may occur either by indirect reduction or by decomposition of CO into C and CO<sub>2</sub>. Part of the carbon monoxide consumed in the upper part must, therefore, have derived its oxygen from the air blast, so that in this case we may have pure indirect reduction.

However, since we do not know how much of the consumption of CO in the upper part is due to indirect reduction and how much to decomposition of CO, we cannot conclude from the concentration of carbon monoxide what the exact amount of the pure indirect reduction is. We can only conclude what the maximum amount of pure indirect reduction is which could possibly have taken place, and which corresponds to the condition that there has been no decomposition whatever of carbon monoxide into C and CO<sub>2</sub> in the upper part of the furnace.

Hence, *if in the blast furnace gas the proportion of carbon monoxide to nitrogen is less than 53 to 100, there exists the possibility of pure indirect reduction in the furnace and half the difference between fifty-three and the volumes of CO per 100 volumes N<sub>2</sub> is the maximum amount of oxygen which can have been removed from the ore by pure indirect reduction.*

In two particular cases Levin and Niedt have shown that the decrease of CO in the upper parts of the furnace was essentially due to indirect reduction and not to the decomposition of CO. In these cases the calculation just sketched gives directly the value of oxygen removed from the ore by pure indirect reduction.

Now the percentage of CO<sub>2</sub> in the gas may be used as a basis for calculating the extent of indirect reduction.

If the concentration of CO is below fifty-three volumes per 100 N<sub>2</sub>, all oxygen abstracted from the ore leaves as CO<sub>2</sub>, but besides this we have other CO, which is driven off from the carbonates in the charge. This latter amount of CO<sub>2</sub> depends greatly on the composition of the charge and especially on the amount of limestone in it. Nevertheless the CO<sub>2</sub> content can be used to get an idea of the minimum amount of indirect reduction.

If *a* is the percentage of CO per 100 volumes N<sub>2</sub> and *b* is smaller than 53 and if *b* is the percentage of CO<sub>2</sub> per 100 volumes N<sub>2</sub>, then the maximum percentage *i* of O<sub>2</sub> which can have been removed from the ore by pure indirect reduction, in per

cents of the oxygen contained in the carbon dioxide in the blast furnace gas, is

$$i = \frac{53-a}{2} \quad \frac{100}{b}$$

**Examples:**

Wedding in his "Handbuch der Eisenhüttenkunde" (vol. III, p. 200 and following pages) gives twenty-one determinations of CO in blast furnace gas made in the years 1839 to 1873. The volumes of the CO per 100 volumes N<sub>2</sub> varied between 12.5 and 65.1, the average being 43.5 volumes CO per 100 volumes N<sub>2</sub>, and the average percentage of the CO<sub>2</sub> was 18.35 volumes per 100 volumes N<sub>2</sub>. From these figures we can calculate the maximum percentage of oxygen which have been obtained from the ore by indirect reduction.

$$i = \frac{53-43.5}{2} \quad \frac{100}{18.35} = 25.8\%$$

or not more than one-fourth of the oxygen contained in the CO<sub>2</sub> of the blast furnace gas can have been obtained by indirect reduction.

C. Brisker (Berechnung des Eisenhochofens, p. 8) gives 12 data from a coke blast furnace, the average figures being as follows:

$$\begin{aligned} \text{CO} &= 42.2 \text{ volumes per 100 volumes N}_2 \\ \text{CO}_2 &= 19.5 \text{ volumes per 100 volumes N}_2 \end{aligned}$$

$$i = \frac{53-42.2}{2} \quad \frac{100}{19.5} = 27.7\%$$

that is, not more than 27.7 per cent of the oxygen in the carbon dioxide in the blast furnace gas can have been obtained from the ore by pure indirect reduction.

O. Simmersbach (Die Eisenindustrie, p. 63) gives five analyses from charcoal furnaces, viz.:

$$\begin{aligned} \text{CO}_2 &= 17.9 \text{ volumes per 100 volumes N}_2 \\ \text{CO} &= 50.4 \text{ volumes per 100 volumes N}_2 \end{aligned}$$

$$i = \frac{53-50.4}{2} \quad \frac{100}{17.9} = 7.3\%$$

In this case less than 10 per cent of the oxygen in CO<sub>2</sub> is obtained from the ore by indirect reduction.

The following figures give the results of analyses of the gas of six modern blast furnaces of one and the same works, each figure being the average of 21 analyses:

Furnace.	Amount of O <sub>2</sub> from in-		
	CO per	CO <sub>2</sub> per	direct reduction in
	100 N <sub>2</sub>	100 N <sub>2</sub>	% of O <sub>2</sub> in CO <sub>2</sub>
I	49.1	18.75	10.38
II	51.0	19.2	5.2
III	49.4	18.3	9.83
IV	50.6	17.55	6.83
V	50.4	19.65	6.62
VI	48.2	18.8	12.77
Average	49.8	18.71	8.6

Niedt and Levin in a previous article (*Metallurgie*, Vol. 8, p. 515, 1911) give the following data from two different modern furnaces in Silesia and Rhineland:

	Amt. of O <sub>2</sub> from indirect reduction in per cent of O <sub>2</sub> in CO <sub>2</sub> .			
	CO per	CO <sub>2</sub> per	"i" is not	"i" corrected.
	100 N <sub>2</sub>	100 N <sub>2</sub>	corrected.	"i" corrected.
Silesia . . . .	51.2	13.8	6.5	9.3
Rhineland . . . .	55.9	10.2	...	...

In the second case no indirect reduction took place. In the first case the CO<sub>2</sub> derived from carbonates in the charge amounted to 29.5 per cent of the carbon dioxide in the blast furnace gas. By taking this into consideration\* we get the above corrected figure of *i*. Since in this case there was no decomposition of carbon monoxide into dioxide and carbon the figure of *i* gives not only the maximum limit, but the actual

\*0.295 x 13.8 = 4.1 CO<sub>2</sub> per 100 N<sub>2</sub> are formed from carbonates. Hence instead of *b* = 13.8 we have *b* = 13.8 - 4.1 = 9.7, hence

$$i = \frac{53-51.2}{2} \times \frac{100}{9.7} = 9.3$$

proportion of the oxygen obtained by pure indirect reduction in per cent of the oxygen of the carbon dioxide in the furnace gas.

Gillhausen (*Metallurgie*, Vol. 7, 1910, p. 421) gives very accurate data from gas analyses from modern practice, each being an average of sixty determinations.

Test No.	CO per	CO <sub>2</sub> per	CO <sub>2</sub> from		O <sub>2</sub> from pure indirect re-
			in % of total	CO <sub>2</sub> in the gas	"i"
I	49.9	20.4	38.8	7.6	12.4
II	52.2	14.4	21.9	2.8	3.6
III	47.2	21.7	26.1	13.4	18.1
IV	58.2	14.1	55.7	...	...
Average	51.9	17.8	34.4	...	...

In Test II there was very little pure indirect reduction and in Test IV none at all. The oxygen due to pure indirect reduction in per cent of the oxygen derived from the ores, can have been at the highest 12 per cent and 18 per cent in the other two cases.

These figures indicate that in the older blast furnaces the maximum amount of oxygen obtained by indirect reduction was in the average about 25-30 per cent of the oxygen in the carbon dioxide in the furnace gas, while in more modern blast furnaces pure indirect reduction is of small importance and sometimes negligible.

**Heat Balance.**

The reaction heats of the direct and indirect reduction processes play an important part in blast furnace operation. We will calculate those of the mixed and pure indirect reduction and compare them with those of direct and indirect reduction.

As a basis for the calculation we use the following data:

- (7)  $\text{Fe} + \text{O} = \text{FeO} + 64.6$  calories.
- (3)  $\text{C} + \text{O} = \text{CO} + 29$  calories.
- (8)  $\text{C} + 2\text{O} = \text{CO}_2 + 96.96$  calories.

The chemical symbols are gramatoms and the calories are kilogram calories. C is amorphous carbon, and O, CO and CO<sub>2</sub> are gases.

By subtracting (3) from (8) we get

$$(9) \text{CO} + \text{O} = \text{CO}_2 + 67.96 \text{ calories.}$$

By subtracting (7) from (3) we get the equation for "direct reduction"

$$(1) \text{FeO} + \text{C} = \text{Fe} + \text{CO} - 35.6 \text{ calories.}$$

By subtracting (9) from (7) we get the equation for "indirect reduction"

$$(2) \text{FeO} + \text{CO} = \text{Fe} + \text{CO}_2 + 3.36 \text{ calories.}$$

Direct reduction, therefore, results in a big loss of heat, indirect reduction produces a small amount of heat. Since the conditions are similar in the reduction of the higher oxides of iron, indirect reduction is generally considered the more economical reaction. (Ledebr, *Handbuch der Eisenhüttenkunde*, Leipzig, 1899, p. 286.)

For "mixed reduction" we have:

- direct reduction (1)  $\text{FeO} + \text{C} = \text{Fe} + \text{CO} - 35.6$  calories.
- indirect reduction (2)  $\text{FeO} + \text{CO} = \text{Fe} + \text{CO}_2 + 3.36$  calories.

For "pure indirect reduction" we have:

- (3)  $\text{C} + \text{O} = \text{CO} + 29.0$  calories.
- (2)  $\text{FeO} + \text{CO} = \text{Fe} + \text{CO}_2 + 3.36$  calories.
- (5)  $\text{FeO} + \text{C} + \text{O} = \text{Fe} + \text{CO}_2 + 32.36$  calories.

Mixed reduction requires, therefore, an expenditure of 32.24 kg calories per gram atom of carbon consumed, while pure indirect reduction generates 32.36 kg calories per gram atom of carbon consumed. Calculated per kilogram of oxygen removed from the ore there is an expenditure of 1005 calories for mixed reduction and a generation of 2020 calories for pure indirect reduction.

This shows the importance of the origin of the CO which takes part in the indirect reduction, the reaction heat per kg of oxygen removed from ore being greater by 3025 calories for pure indirect reduction than for mixed reduction.

The following is a summary of the reaction heats of the dif-

ferent kinds of reduction in kilogram calories per gram atom of iron reduced:

Direct reduction:  $FeO + C = Fe + CO - 35.6$  calories.

Mixed reduction:  $FeO + \frac{1}{2}C = Fe + \frac{1}{2}CO_2 - 16.12$  calories.

Pure indirect reduction:  $FeO + C + O = Fe + CO_2 + 32.36$  calories.

These results show that mixed reduction is more economical than direct reduction, since it consumes only half of the carbon and less than half of the energy per unit of iron reduced.

In all three equations the quantities of  $FeO$  reduced and  $Fe$  produced are the same, so that the differences in the reaction heats must be due to the different quantities of carbon consumed and the difference in the degree of oxidation of the carbon.

This is proved by the following equations:

mixed minus direct reduction  $\frac{1}{2}(2CO) = \frac{1}{2}(C + CO_2) + 19.48$  calories.

pure indirect minus mixed reduction  $\frac{1}{2}(C + O_2) = \frac{1}{2}(CO_2) + 48.48$  calories.

pure indirect minus direct reduction  $CO + O = CO_2 + 67.06$  calories.

Finally, attention may be called to the fact that according to these equations the differences between direct reduction, mixed reduction and pure indirect reduction are independent of the nature of the metal (iron in the above case) which is being reduced from its oxide. The same is true for the difference between indirect and direct reduction, for which we have the equation:

$$2CO = C + CO_2 + 38.96 \text{ calories.}$$

Iron and Steel Metallurgical Laboratory,  
Institute of Technology,  
Aachen, Germany.

The Mexican Mining Journal, published at Mexico City, sustained a complete loss of its plant by fire on April 20. The May issue of the Journal was in press and was destroyed. Through the courtesy of local printers the owners of the Journal have been enabled to continue publication until a new plant can be obtained.

## Variation of the Electrical Resistance of Oxides with Temperature

By A. A. SOMERVILLE.

Since studying the effect of temperature upon the resistance of many of the so-called electrical conductors found in a laboratory, the writer has found an interesting field for work in the investigation of the non-conductors under ordinary conditions, if these materials are subjected to higher temperatures.

Also as most metals and alloys oxidize when subjected to higher temperatures in air, it seems just as natural to investigate the products of oxidation as to try to prevent oxidation by excluding oxygen.

For these reasons the work has been begun of trying to measure the resistance as a function of temperature of the oxides.

As a rule, oxides at room temperatures are non-conductors. As the temperature is increased, the resistance decreases until at 1000 deg. C. most of them may be classed as conductors.

The oxide in the form of a powder is placed in a porcelain or quartz tube, Fig. 1, about 1 cm. in diameter and 10 cm. in



FIG. 1—TUBE FOR MEASURING RESISTANCE OF OXIDE POWDER.

length. Nickel rods are machined to fit into the ends of the tube against the ends of the column of oxide, which is about 5 cm. in length. Two to 4 lb. pressure is put on the ends of the nickel rods by means of weights in order to effect constant pressure and constant contact on the oxide. The oxide in its containing tube is heated in a tubular resistance furnace. The temperature is measured with a platinum resistance thermometer. Electrical contact is made with the ends of the nickel rods for measuring the resistance of the oxide. A Wheatstone bridge is used for this purpose.

There is a marked similarity in the way in which the resistance of the different oxides varies with temperature. The

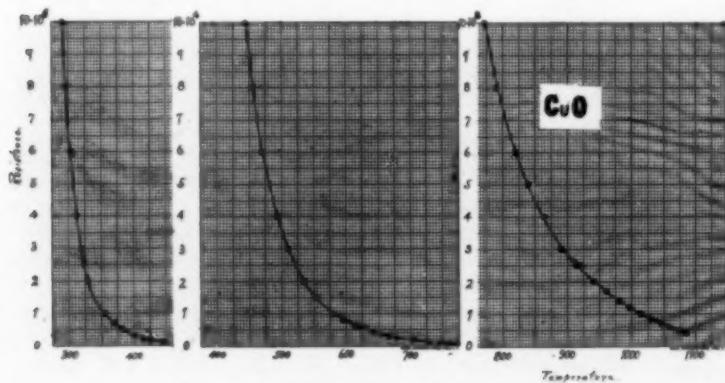


FIG. 2.—CURVES FOR  $CuO$  (FIRST HEATING).

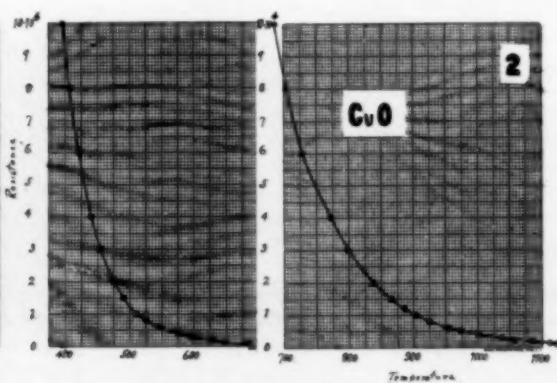


FIG. 3.—CURVES FOR  $CuO$  (AFTER ONCE HEATED).

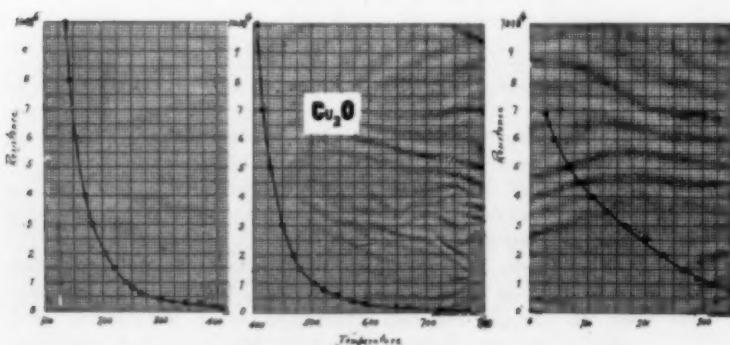


FIG. 4.—CURVE FOR  $Cu_2O$  (FIRST HEATING).

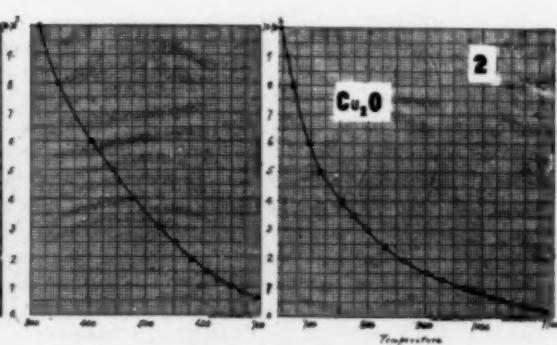


FIG. 5.—CURVE  $Cu_2O$  (AFTER ONCE HEATED).

maximum resistance reading made is 10,000,000 ohms. This reading occurs at different temperatures in different oxides. However, the general form of all the curves is nearly the same.

The materials that have been studied to date are:

Zinc oxide.....	ZnO.
Ferric oxide.....	Fe <sub>2</sub> O <sub>3</sub> .
Cupric oxide.....	CuO.
Cuprous oxide.....	Cu <sub>2</sub> O.
Magnesium oxide.....	MgO.
Manganese dioxide.....	MnO <sub>2</sub> .
Aluminium oxide.....	Al <sub>2</sub> O <sub>3</sub> .

The same cross-section and length of each has been used, that is, 1 cm. diameter and 5 cm. length. Variations from this

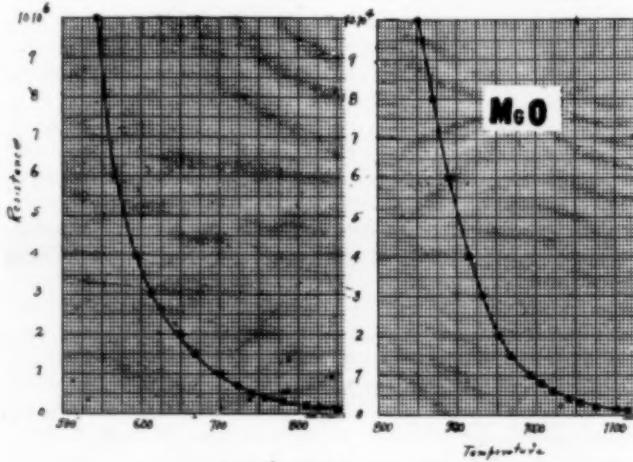


FIG. 6.—CURVE FOR MgO.

have been made only to show that contact resistance is negligible.

The temperature at which each measures 10,000,000 ohms is here indicated. Temperatures are in Centigrade degrees.

ZnO .....	393 deg.
Fe <sub>2</sub> O <sub>3</sub> .....	252 deg.
CuO .....	290 deg. (First heating.)
CuO .....	395 deg. (After once melted.)
Cu <sub>2</sub> O .....	137 deg. (First heating.)
Cu <sub>2</sub> O .....	After first heating, measures 90,000 ohms at 0 deg. C.
MgO .....	545 deg.
MnO <sub>2</sub> .....	120 deg.
Al <sub>2</sub> O <sub>3</sub> .....	?

The resistance of these materials at a temperature of 1100 deg. C. near the maximum of the furnace is the next most

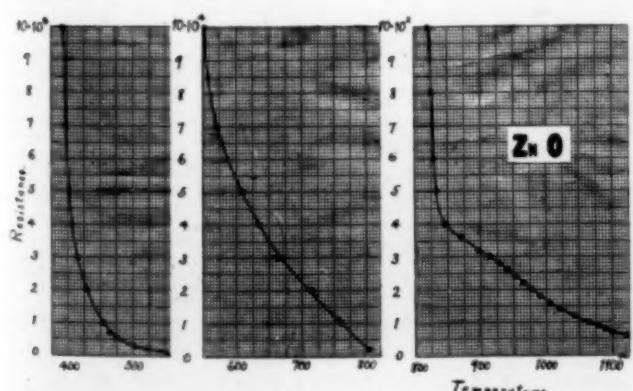


FIG. 7.—CURVE FOR ZnO.

interesting thing learned. The resistance is given in ohms.

MgO .....

Cu<sub>2</sub>O .....

Changed to (Cu + CuO) at about 800 deg. C.

Cu <sub>2</sub> O .....	18. (After first heating.)
CuO .....	35 at 1084 deg. C. (Melting point.)
CuO .....	1600. (After once melted.)
MnO <sub>2</sub> .....	70.
ZnO .....	72.
Fe <sub>2</sub> O <sub>3</sub> .....	80.
Al <sub>2</sub> O <sub>3</sub> .....	? (Infinite.)

The curve sheets, Figs. 2 to 8, are scaled to various powers of "tens" in order to show the entire curve to the best advantage.

Black copper oxide, CuO, melts at 1084 deg. C. and contracts to about one-half its former volume. The surface ten-

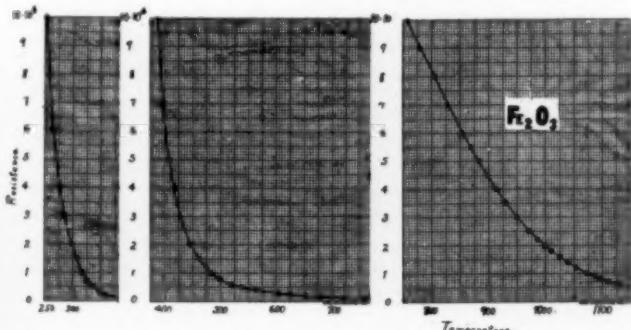


FIG. 8.—CURVE FOR Fe<sub>2</sub>O<sub>3</sub>.

sion is such that it retains its cylindrical form. The value of the resistance is at all temperatures greater after the oxide has been once melted.

Red copper oxide, Cu<sub>2</sub>O, undergoes a change at about 800 deg. C. here indicated. Cu<sub>2</sub>O = Cu + CuO. The metallic copper then begins to unite with the oxygen of the air to form more black copper oxide, CuO. Only the metallic copper at the surface, however, is exposed to the air and the copper in the interior remains metallic, being protected from the oxygen

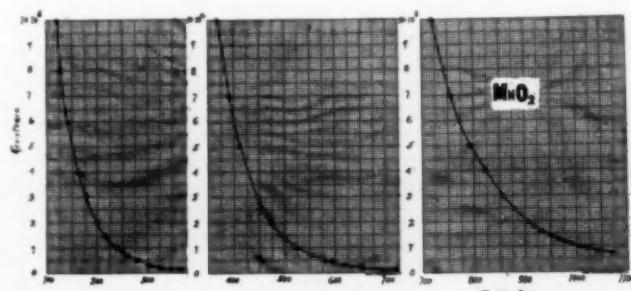


FIG. 9.—CURVE OF MnO<sub>2</sub>.

of the air by the outer layer of oxide. The metallic copper formed tends to make the resistance of the mixture lower than it had been at any corresponding temperature before the formation of the metal occurred.

Aluminium oxide appears to be one of the best insulators. Magnesium oxide is also used as a non-conductor.

Ithaca, N. Y.

The average tenor of zinc and lead sulphide concentrates in different states is shown in the following table, which has been compiled from statistics of the United States Geological Survey for 1911:

	Per cent Metal Crude Ore.	Per cent Lead in Lead Zinc Conc.	Per cent Zinc in Zinc Conc.	Value per ton, Lead Zinc Conc.
Oklahoma:—				
Miami Dist....	2.4	4.3	78.3	\$53.55
Quapaw Dist....	0.4	1.7	79.3	55.32
Illinois:—				
Northern .....	0.4	3.2	79.4	45.3
Southern .....	..	..	70.0	44.00
Arkansas .....	0.2	3.2	80.0	50.2
Kansas .....	0.4	1.5	78.9	56.0
Wisconsin.....	0.3	3.1	76.9	34.6
				52.41
				20.53

## Notes on Chemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

### The National Physical Laboratory.

The report for the last year, which has just been issued, is a fairly satisfactory document. In many respects the severest critics of the laboratory can take no exception to a great deal of its activities. A feeling of soreness, however, in regard to its doing commercial testing is still a point of irritation to many men in private practice. That, however, is by the way, because the chief interest to your readers will be in what the laboratory has achieved rather than in our domestic quarrels. There has been an enormous increase in work, and issues of certificates have been as follows:

#### Physics Department, Electrical Measurements

Measurement Section .....	269	as against	172
Electrotechnic Section .....	2203	"	1810
Photometry Section .....	920	"	480
Thermometry Section .....	582	"	496
Optics .....	5106	"	5308
Metrology .....	2974	"	1860
Engineering Department .....	283	"	159
Observatory .....	37,145	"	36,395

The financial situation is as follows: The income again shows a satisfactory growth, having risen from £28,076.12.1 in 1910 to £30,336.15.8 in 1911, an increase of £2,260.3.7. This is mainly due to an increase in the receipts for work done, which have risen from £15,363.0.9 in 1910 to £17,398.3.7 in 1911. The receipts for 1910, as here given, include one-half year's dividends from the Gassiot Fund, amounting to £234.13.7 and also a payment by the Meteorological Office of £200 for one-half year's work done. Both these payments lapsed as from July, 1910, and the increase in 1911 in receipts for work done, excluding the meteorological work now transferred to the Meteorological Office, is therefore really greater by these two amounts than would appear from the totals. On the other hand the total for 1911 includes the sum of £687.3.2 for work done by the Tank Department, which this year contributes to the receipts for the first time. The sum received from the Institution of Naval Architects on account of the Guarantee Fund for the Tank has been £1,316.15.0 as against £1,327.5.0 in 1910.

The total expenditure for the year 1911 has been £30,571.14.10, exceeding the receipts by £234.19.2. This expenditure includes a sum of £640.6.0 spent on general equipment, with a further sum of £63.7.11 for accessories to the Lorenz Apparatus. The sum of £352.6.1 was also provided out of the General Maintenance Account toward the expenses of the William Froude National Tank, while a further amount of £111.3.0 was spent on certain items of equipment for the Tank.

Space in this letter only permits of reference to part of work done in 1911. The processes of analysis in use in the Division of the Department of Metallurgical Chemistry have continued to give complete satisfaction. Special attention has been given to the whole question of carbon determination in steel by the two processes of direct combustion in oxygen and the previous separation of the carbon by means of copper-potassium chloride. As a rule it has been found—over a very large number of samples—that the two methods give identical results, but in a certain group of steels, which were tested by both methods at the request of a steel-maker, serious discrepancies were found, the copper-potassium-chloride method giving distinctly higher results. It was subsequently discovered that these high results were due to the presence of organic impurities (probably dissolved cellulose) in the copper potassium chloride solution. Although such cellulose is precipitated when the solution is acidified, the quantity is too minute to be seen and remains present as a finely-divided flocculent precipitate. This contamination was found to be present in

the "pure" variety of the double chloride as supplied by a chemical manufacturer of high standing, so that care in the use of this reagent is obviously needed. This experience has served to strengthen the view held as the result of experience at the laboratory, that the method of direct dry combustion is the most uniformly reliable for carbon steels.

In the new electrochemical room provided in the New Building, a beginning has been made in setting up apparatus and methods for a more extended use of electrochemical methods of analysis.

*Investigatory Test Work.*—A considerable amount of this class of work has been carried out by the Chemical Division of the department.

A series of samples of pitch and bitumen have been examined and tested for Colonel Crompton on behalf of the Road Board; a room in the new building set aside for this work (together with cement analysis) affords special facilities for the investigation of such materials. A report on methods of testing such substances has also been drawn up.

The chemical properties of a series of samples of optical glass have been determined, interesting results as to the relative durability of such glasses of British and Foreign manufacture being obtained.

The special investigation on the inflammability of flake charcoal mentioned in the previous report has been continued and is now nearly completed. These experiments show clearly the danger of fire which is involved in using sulphur dioxide for disinfecting purposes in places where charcoal is used in the walls. The behavior of decayed wood has also been studied from the point of view of spontaneous combustion, but as far as the samples yet tested are concerned, this material appears to be markedly less inflammable than charcoal—i. e., its temperature of spontaneous combustion is very decidedly higher.

#### Alloys of Aluminium and Zinc.

At the meeting of the Institution of Mechanical Engineers on the 19th of April, the Alloys Research Committee's tenth report was presented by Dr. W. ROSENHAIN and Mr. S. L. ARCHBUTT. The authors attributed the usual rapid corrosion of commercial samples of these alloys to the impurities in the spelter used in preparing them; and found that pure zinc gave alloys with much less tendency to corrosion or to cracking on cooling. They claim to have discovered that a compound  $Al_2Zn_3$  is formed. The results of dynamic tests in conjunction with those of tensile tests indicated that the most useful binary alloy was that containing 20 per cent of zinc.

In the course of the discussion Sir Gerard Muntz objected that the results given in the report were obtained from alloys prepared with pure zinc. It was not necessary to use zinc of such a high degree of purity as had been employed for these investigations; the commercial quality was good enough and would be used in practice.

Sir H. F. Donaldson remarked that he had obtained results varying considerably from those given in the report; but as nearly all his alloys contained about 1 per cent of copper a strict comparison could not be made.

Mr. L. Archbut, Jr., said that the authors had used sea water for the corrosion tests. He thought that the substances employed for such tests should be selected according to the purpose the alloy was to be used for, and suggested that it would be preferable to ascertain the action of oils and fatty acids.

The meeting was then adjourned until Friday, the 3d of May, when Professor Arnold is expected to resume the discussion.

It is difficult to reconcile some of the statements in the text of the report with the figures in the tables referring to the same question, viz., the effect of ageing; and the contradictions are so manifest that the authors will most probably be asked to give an explanation at the adjourned meeting.

At the meeting of the Institution of Mechanical Engineers on the 3d of May, the discussion on the tenth report of the Alloys Research Committee was resumed by Mr. S. L. Archibutt, one of the authors, who remarked that sometimes the yield point was a little higher when zinc of commercial quality was used for the alloys; but with pure zinc the ultimate stress was invariably much higher. The thermal expansion of alloys containing from 5 to 15 per cent of zinc was about twice that of steel.

Professor Arnold regretted that the authors had not paid greater attention to mechanical tests. The decision of the engineer was final; and it was necessary that he should have these results. It appeared that the endurance of the alloys under alternating stress was only from one-eighth to a quarter of that of good mild steel, and that was a vital matter. In research of this class the collaboration of the practical metallurgist was necessary to insure its full value to mechanical engineers.

Mr. W. Mills said that he was one of the first to deal practically with aluminium-zinc alloys, and directed attention to the difficulties encountered in making castings. He had obtained the best results with an alloy the composition of which closely approximated to that which had come out best in this research. There was, however, a demand for a lighter alloy with almost the same specific gravity as aluminium.

Mr. F. W. Harbord remarked that the impurities mostly existing in commercial zinc were iron and lead; and it would be useful to ascertain which of these caused the difference between alloys containing commercial zinc and those with pure zinc. He quite agreed with Professor Arnold on the question of practical tests.

Mr. E. F. Law said the authors referred to two undesirable properties in these alloys, namely, the tendency to crack on cooling and abnormal corrosion; and they then dismissed these aspects somewhat perfunctorily. They admitted that these views were widely held by practical men; and he thought it desirable that such men should present their opinions. With regard to the use of pure zinc, practical founders were asked to make much more complicated castings than those described, and they were not presented with chemically pure zinc by Sir John Brunner. A point to which he desired to draw attention was that the authors stated on p. 9 that no signs of change were observed after fifteen months ageing; and yet the table on p. 32 gave decisive evidence of the effect of ageing; for the ultimate stress and yield point had risen in every case. The authors seemed to have misinterpreted their own results.

Mr. R. F. Graham spoke as a practical man on the subject of castings, and urged the necessity of very carefully regulating the casting temperature as an essential condition for the production of sound castings with aluminium-zinc alloys.

Mr. P. Armstrong, on the question of ageing, said he had found it necessary to season the castings before machining or threading them. The electrical conductivity of these alloys was about the same as that of aluminium.

Dr. Rosenhain, in his reply, said it had been necessary to make a selection out of a great diversity of methods of research; and those which seemed most generally desirable had been adopted. With reference to Mr. Fowler's remarks as to the desirability of testing the alloys under practical working conditions, he suggested the construction of a railway bridge.

#### International Aluminium Syndicate.

There is some probability that the International Syndicate which dissolved in the autumn of 1908 will be re-constituted in about three months' time. A conference of the French, English, American and Swiss makers was recently held in Paris, and it is reported that an agreement was arrived at as to the establishment of a basis for combined operation. Negotiations are expected to reach their conclusion in June or July and to result in the speedy establishment of the syndicate. The fact

that continental prices have risen eight or nine shillings per cwt. during the past six months is in some quarters attributed to anticipation of the successful resuscitation of the combination.

#### Engineering Imports and Exports.

The returns issued by the Board of Trade for the four months ended April 30th give the value of imports of iron and steel, including manufactures, as £3,683,797, a decrease of £60,541 from the figures for the same period in 1911; but the exports show an increase of £249,369 with a total of £15,007,223. Other metals, including manufactures, were imported to the amount of £9,909,819, an increase of £1,009,752; and were exported to the value of £3,628,757, also an increase of £46,219. The imports of electrical goods reached £530,812, and the exports £1,443,277; showing increases of £62,638 and £54,597 respectively. Imports of machinery are put at £2,214,538, a rise of £179,477; and exports at £10,370,236, a rise of £275,432. Imports of new ships amounted to only £11,597, a decrease of £33,303; while exports valued at £1,716,933 improved by £18,505. The figures for the month of April only are not altogether satisfactory. Both imports and exports of iron and steel decreased, the respective falls amounting to £173,655 and £1,041,557. Imports of other metals fell £48,959 and exports also fell £113,538. Imports of machinery improved by £9,533; but the exports were £57,153 lower. There was an increase of £8,927 in imports of electrical goods, and an increase of £47,881 in exports.

The Stassano Electro Steel and Furnace Company has not proved a commercial success and is voluntarily winding up. Mr. Augustus Hobbs, of Highbury, has been appointed liquidator.

#### Market Prices, April and May, 1912.

*Copper* has kept pretty much the same level during April. Opening at £70.10 it fell to £69.5, on the 10th, recovered, and remained over £70 till the 19th, when the price declined slowly to £69.10. On the 24th the price again recovered to over £70, and has remained in the neighborhood of this price, closing at £70.12.6.

Copper opened in May at £70 and after a slight decline to £69 rose steadily to £74 (17th). Since then it has continued to appreciate, general activity of Continental and Colonial trade assisting the withdrawals from stock. Closes at £76.00.

*Tin* was considerably affected in April by shortening stocks, and has shown a strong upward tendency throughout the month. Starting at £198 it touched £196 during the second week, rose to £203 in the fourth and closes at £211.10.

In May tin opened at £211, dropped to £208 on the 6th, again rose to £212 on the 13th, and £212.15.0 on the 16th, afterwards fell sharply to £205 (22nd), since recovered to £208, but closes £204.0.0.

*English Lead* was quiet in April, with upward tendency, opening at £16.10, and closing £16.17.6.

In May English lead has shown an upward tendency; starting £16.17.6 and closing £17.2.6.

*Pig Iron, Scotch*, rose sharply after Easter, opened at 58/-; had reached 60/- by the 10th; afterwards fell away slightly, but recovered ultimately to 60/- (Glasgow settlement).

In May pig iron, Scotch, has kept in the neighborhood of 60/-, with dip to 59/4 on the 9th. Closes at 59/10 1/2.

*Cleveland* jerked up in the same way as Scotch Pig, opening 51/10, rose to 54/- at mid-month, declined during the following week, and closes at the same price, 54/-.

In May Cleveland has kept up in the neighborhood of 54/-, opening at that price, touching 53/3 on the 9th, and closing at 53/10 1/2.

*Haematite*, after rising from 65/10 to 69/- (commencing its strong movement on the 11th) held up, and ultimately closed at 69/0.

In May Haematite has been strong, opening at 70/-, touching 69/6 on the 9th, and closing at 71/-.

The following prices are for May 1912:

	£ s. d.
Alum lump, loose, per ton.....	5.15.0
Antimony, black sulphide powder, per ton.....	20. 0.0
Borax, British, Refined Crystal, per ton.....	16.10.0
Copper ore, 10 to 25%, per unit.....	13/- to 13.6
Copper sulphate, per ton.....	25. 0.0
Carbolic acid, liquid, 97 to 99%, per gal.....	1.7
Creosote, ordinary good liquid, per gal.....	3½
Camphor, 1 oz. tablets.....	1.7½
Caustic soda, ash 48% ordinary, per ton.....	5.10.0
Hydrochloric acid, per cwt.....	5.0
India rubber, Para, fine, per lb.....	4.6½
Mica, small slab, original cases, per lb.....	6d to 2.0
Naptha, solvent, 90%, 160 deg. C., per lb.....	9½
Petroleum, Russian spot.....	8½
Quicksilver, per bottle.....	8. 5.0
Sal ammoniac lump, firsts, delivered U. K. per ton	44. 0.0
Sulphate of ammonia, f.o.b. Liverpool, per ton.....	14.17.6
Sulphur, recovered, per ton.....	5. 0.0
Shellac, standard T. N. Orange spots, per cwt.....	4. 4.0
Tin ore, 70 per cent, per ton.....	£135 to 137. 0.0
Zinc, Vieille Montagne, per ton.....	29. 7.6
Platinum, nominal, per oz.....	9. 5.0

The differences on the month of May are thus:

*Higher.*

	£ s. d.
Copper ore unit .....	7½
Copper sulphate, ton .....	10.0
Creosote per gal.....	3½
Naptha, per gal.....	3½
Sulphate ammonia, ton .....	7.6
Tin ore, per ton.....	6. 0.0
Copper, ton .....	6. 0.0
Lead, ton .....	5.0
Haematite .....	1.3

*Lower.*

	£ s. d.
India rubber, lb.....	1½
Tin, ton .....	7. 0.0

**Zircon** exists in sandstone deposits near Ashland, Va., and samples taken from deposits on a number of farms show considerable percentages of the mineral. Should the demand for zircon prove sufficiently great it is probable these deposits could be worked at a profit. A combination of wet dressing and magnetic separation could be used to separate the mineral.

The production of phosphate rock in the United States continues to increase steadily. The United States Geological Survey reports that in 1911 the production was 3,053,279 tons, valued at \$11,900,693. New ground was prospected in Kentucky last year, and it is probable that phosphate eventually will be produced in that state. Continuation of work on Western deposits has increased the estimates of tonnage, and has discovered some new deposits in Montana. The Western deposits are now estimated to contain more than 2,500,000,000 tons of minable rock carrying 70 per cent or more tricalcium phosphate.

The output of gold from the Transvaal in 1911 is estimated to constitute about 38 per cent of the world's production for that period.

The average value of copper rock treated in Michigan in 1911 was \$2.50 per ton. The recovery of refined copper per ton of rock treated was 20 lb. The quantity of silver recovered was 497,281 fine ounces, of which 513 ounces were recovered as pickings, and 496,768 ounces from electrolytic treatment of 43,755,777 lb. of copper.

The Elmore oil-vacuum concentration process in use at the mines of the Sulitelma Company, Norway, produced 975 tons of copper concentrates in May, 1912.

## The Western Metallurgical Field.

### New Montana Mills.

The Butte Central Copper Company is erecting a combination concentration-cyanidation mill at the foot of South Dakota Street, Butte, Mont. The mill is being constructed in units of 100 tons each, and for the present an initial capacity of 200 tons will be completed. The arrangements are such that a plant of 500 or 600 tons capacity per day can be erected. The various steps in the process are as follows: Mine ore will be crushed to  $\frac{3}{4}$ -in. size and stored in the main mill bins, from which it will be fed to Chilean mills fitted with 24-mesh screens. At this stage in the crushing the pulp will be concentrated to remove coarse sulphide mineral, which contains lead, copper, iron, zinc. The tailing will be classified by Akins classifiers, producing sand and slime, the former being reground in a 5-ft. by 22-ft. tube mill. The slime will be thickened and again subjected to concentration on Deister tables, care being taken to eliminate all minerals that would be detrimental to the subsequent cyanide treatment. From 60 to 65 per cent of the value of the ore will be recovered by this double concentration.

Preliminary to cyaniding the tailings from concentration they will be dewatered to a comparatively dry state. Cyanide solution will be added, and the mass agitated in a continuous system of Rothwell-Akins agitators for a period of thirty hours. Experiment has shown that an extraction of 86 per cent of gold and silver can be obtained by this procedure. Portland continuous vacuum filters will be installed to separate solution and slime, and zinc shavings will be used for precipitation. A feature of the cyanide treatment will be the application of the continuous counter-current system which was described in this journal by Mr. John E. Rothwell, July and September, 1911, pages 373 and 439.

The sulphide minerals obtained in the double concentration will be subjected to further dressing to separate the lead, copper, iron and zinc into suitable shipping products. Careful preliminary tests have preceded the plan and construction of this mill, and it is believed that the system can be successfully adapted to the treatment of the low-grade silver ores of the Butte district.

**Flotation at Butte & Superior.**—The new zinc concentrating mill of the Butte & Superior Company, at Butte, Mont., was designed as a result of long experimentation, including commercial treatment of the ore at the old Basin Reduction Works. An important feature of the treatment employed is the use of a flotation system. No data are given out by the company regarding the work at the mill, but some idea of the flotation process can be gained from the description given in patent papers. The patentee is James M. Hyde, of Basin, Mont.

The process makes use of acid and oil, but does not involve the use of a vacuum. A coagulant, such as ferrous sulphate, may be used to facilitate the settlement of colloidal matter. The ore is first mixed with acid before thickening, as it has been found that this reduces the amount of acid required. The pulp is then thickened and pumped to a series of connected agitation and flotation tanks. In the first of these oil is added and the entire mass agitated. Concentrated mineral floats and is removed, while the remainder of the pulp is removed and pumped to a second agitator and flotation tank similar to the first. Here a second concentrate is produced, and the tailings may be re-treated in a third tank, from which tailing is finally discharged. The concentration from the several foregoing floatations are now combined and cleaned in a second series of similar tanks.

The process is applicable to fine material, an example of which follows: A slime pulp consisting of quartz, blende, and granite, in which the feldspars were largely kaolinized, contained 30 or more parts of water to one of dry slime. Before thickening, it was treated with from  $\frac{1}{4}$  to  $\frac{1}{2}$  lb. sulphuric acid per ton of ore. The thickened pulp was heated with live

steam and mixed with "candle makers' red oil." The original pulp carried 23.3 per cent zinc, the concentrate 51.4 per cent, and the tailing 3.2 per cent, showing a 91 per cent recovery. In the first treatment the concentrate contained from 38 to 42 per cent zinc, and this percentage was raised, as above shown, in the second treatment.

In addition to the use of flotation, the Butte & Superior system makes use of classifiers, jigs and tables. Jigging begins at 6 mesh, and the oil flotation is used on 100-mesh and finer material.

**Timber Butte Mill.**—W. A. Clark has organized the Timber Butte Company to build a concentrating plant to treat the zinc and copper ores from the Elm Orlu Mine. This plant will replace the old concentrator at the Butte Reduction Works, which was burned last year. The new mill will be located on Timber Butte, about 2 miles south of Butte, and will have a capacity of 350 tons per day.

#### Increasing Activity in Colorado.

The long talked of mill at the old Newhouse tunnel, now known as the Argo tunnel, at Idaho Springs, is to be erected this summer. Following the general plan of the Hudson mill, which was described in this journal for January, 1912, the new plant will be adapted to make recovery by amalgamation, concentration and cyanidation, and will be operated as a custom plant. The great variety of ores encountered in this district makes it impossible to rely on any one system of metallurgy to recover the valuable minerals, hence the combination above mentioned. A sampling plant of 300 tons daily capacity will be erected in connection with the mill, but for the present only one unit of the mill of 100 tons capacity will be erected. This capacity will be increased to 300 tons as needed. It is expected that the erection of this mill will permit an increased production of low-grade ores, which at present are not mined, as well as an increased profit from other ores which are now sold at a disadvantage.

It is reported that the El Paso Consolidated Mining Company, one of the large producers in the Cripple Creek district, has interested additional capital in its operations, and that a mill will be erected in the district for the local treatment of low-grade ore. While the details of the mill have not been announced, it is probable that the metallurgical process to be employed will follow the general plan which has proven so successful in the Stratton's Independence and Portland mills.

The suit of the Smuggler-Union Mining Company against the Liberty Bell Mining Company, both of Telluride, was tried in the Federal Court in Denver during the first week in June. The former company alleged trespass and unlawful extraction of 74,000 tons of ore which was treated in the Liberty Bell mill. The damage asked amounted to \$600,000, and the verdict awarded the sum of \$403,000 to the plaintiffs. Toward the end of the trial the defendant admitted innocent trespass and placed the amount of ore extracted at 53,000 tons. The plaintiff was granted twenty days in which to file a motion for a new trial.

#### New Work in Utah.

Increased capacity at the smelter of the International Smelting & Refining Company, Tooele, is being provided to accommodate the growing shipments of lead ore. A new lead furnace will be erected, making the third, and four sinter roasters will be installed. In the copper smelting department four of the five reverberatories are in commission, and the combined lead and copper furnaces are treating about 1000 tons of ore per day.

The Columbus Consolidated, which is an old producer in the Alta district, is planning to remodel its concentrating plant and bring it to a high state of efficiency in accordance with modern practice. Recent development of new bodies of concentrating ore has made this step advisable, and the necessary alterations will be made as rapidly as possible in order to make the new discoveries profitable.

Consolidated Mercur, which was one of the first companies in this country to make successful application of the cyanide process and vacuum filters, has about reached the end of its profitable existence. The company notified stockholders of a 3-cent dividend last month, and stated at the same time that unless unusual developments resulted in the next few months operation would be discontinued. The stockholders were requested to take action which would permit the directors to dispose of the salable equipment, in order that the affairs of the company might be wound up with as little expense as possible. During the past few years the company has sought other properties where its present equipment might be of service, but it has been unable to find anything suitable.

#### Inspiration Consolidated Mill.

This company, which owns a large acreage of porphyry copper ground in the Miami district, has decided on the site of its new 7500-ton concentrating mill, and has commenced construction work. The mill will be located about one mile north of the town of Miami, and one mile east of the mine. The ore-dressing system has been developed by J. M. Callow, of Salt Lake, and will be along the line developed in the mills of the Utah Copper Company. The mill will be erected in six units of 1250 tons capacity each.

#### Culture in the Education of Engineers.\*

BY WILLIAM L. SAUNDERS.

At one of the meetings of the American Institute of Mining Engineers, held in the hall of the Sheffield Scientific School at New Haven, a discussion arose as to whether or not sufficient importance was given to cultural studies in our scientific schools. A diagram was exhibited showing graphically the relative proportion that culture bore to other studies in the various colleges. In some there was a wide distribution of cultural work, in others the proportion was small, and in a few cases it was shown that these studies were entirely omitted in the curriculum. During recess a group of students were discussing the subject; one of them, a senior, said, "I don't see why they should *learn* a person culture in a scientific school." This remark, made in my presence, so impressed me as a concrete example of neglect in true educational lines that it has been chosen as a text for what is to follow.

Education in its broadest sense is mental and moral training. High schools and colleges differ from common schools in that they aim at higher planes of mental and moral life. The small boy is taught by stuffing, as one puts sawdust in a doll; this is because his mind has not grown to the stage when it can think for itself. Impressions are received and transfixed by memory; the process is one of mental photography; the moral code is learned by rote as though it were the multiplication table. Not so with the older, the college student; his highest aim in education is to learn to think for himself. "If you are a student force yourself to think independently; if a teacher compel your youth to express their own minds," writes Dr. Osborn of Columbia; and again, "The lesson of Huxley's life and the result of my own experience is that productive thinking is the chief *means* as well as the chief *end* of education."

Now what is productive thinking? Let me answer this question by giving you Huxley's definition of culture: "The pursuit of any art or science with the view of its improvement." The storage process is of paramount importance only when applied to elementary education. It is but the auxiliary of the scholar who has passed from the junior to the senior stage of student life, and who aims to do things in the world. The pursuit of facts is a mathematical study. We learn of things that exist as a result of divine and human creation. The earth is round and it is composed of land and water. Water is

\*Address delivered at the 38th Annual Commencement, Colorado School of Mines, Golden, Colo., May 24, 1912.

hydrogen and oxygen combined. The square of the hypotenuse of a right angle triangle is equal to the sum of the squares of the other two sides. How elementary are these facts! It is important that we should know them; but even a large volume of facts when stored in the human mind is powerless to add one cubit to progress. It is like putting a pair of legs on the *Encyclopedie Britannica* and expecting it to do something. Knowledge is power, but reason is power in action.

Dr. James Gayley, of the United States Steel Corporation, told me recently that the professor at Lafayette College who taught him how to think made so deep an impression upon him that it has lasted throughout his life. Mr. Gayley is distinguished for what he has done as a metallurgical engineer. His life has been one of productive thinking; he has pursued science with the view of its improvement. That teacher, Mr. Gayley said, once gave him a solution containing iron, and instead of instructing him how best to precipitate the metal he told him to try three or four ways of doing it and report which was best. This led directly to thought and reason and built up a master mind among engineers. We may still heed the voice of old Carlyle crying from the heathery hills of Dunscore: "Produce! Produce! Were it but the pitifullest infinitesimal fraction of a product, produce it in God's name! 'Tis the utmost thou hast in thee; out with it, then."

Where among all the professions do we get the results that come through productive thinking as from engineering? The engineer is the architect of the world's progress. Transportation in railways and ships, in motor cars and aeroplanes, is the productive thinking of mechanical engineers woven into our industrial life. The men who did these things were students of science, not that they might be mere storehouses of knowledge, but that they might produce. Civil, electrical, chemical and mining engineers are fields which afford infinite opportunities for research and progress. If you men of the future do not rise to your chances in these lines it is not because the fields are not still open for cultivation and growth, but rather through your own inefficiency or perhaps your top-heaviness.

"In vain our toil,

We ought to blame the culture, not the soil."

Even Huxley feared that men might be over-fed scientifically when he said: "An exclusively scientific training will bring about a mental twist as surely as an exclusively literary training. The value of the cargo does not compensate for a ship's being out of trim; and I should be very sorry to think that a scientific college would turn out none but lop-sided men."

All this bears upon culture in its broadest sense. Productive thinking is the most important form of culture. It makes for power, refinement, knowledge, taste, civilization. The subject, you see, is a very broad one; the obligation upon you as students of science is equally broad. Take care that you be not "lop-sided men." A graduate of the Colorado School of Mines, like all graduates of the higher institutions of learning, misses his opportunities and discredits his college if he does not carry throughout all his walks of life the imprint of the educated man. Noblesse oblige is a degree and an obligation which is uniformly conferred upon all college men. To carry this obligation properly one should study culture in all its phases and in its broadest sense. Study it as an undergraduate and study it still harder and more fully through all your post-graduate life. To this end let us accept and profit by that definition of culture given us by Matthew Arnold: "Acquainting ourselves with the best that has been known and said in the world." A professor at Wellesley College defined culture to the students as that which is left after all else learned at college is forgotten.

Virtue and moral training belong to cultural work in the education of engineers. It is a mistake to suppose that schools and colleges are places for mental training only. Physical exercise through athletics is just as much a part of one's college life nowadays as the study of mathematics; the one helps the other. Emerson said, "Archery, cricket, gun and fishing

rod, horse and boat, are all educators, liberalizers." To the engineer physical training is of value in order to fit him for outdoor work. Moral training is of even greater importance. Locke has placed virtue first in defining the objects of education. Wisdom he puts next, and then good breeding; last of all learning. It is more the province of the teacher than of the student to safeguard and train the character by precept and example, for, after all, "the foundation of culture, as of character, is at last the moral sentiment. This is the foundation of power."

It is a common saying that manners make the man. Good manners afford us easy weapons with which to win friends and to conquer enemies. Manners adorn the gentleman and smooth the way of the educated man through the world. Manners are never born in men; but they are bred by association and study. Like oil on the journals of an engine, they avoid friction and aid efficiency. There are many reasons why we should be polite, but the best reason is because it pays; it costs nothing. It is said of William Earl of Nassau that he won a subject from the King of Spain every time he put off his hat. So engaging were the manners of Charles James Fox that Napoleon said of him on the occasion of his visit to Paris in 1805: "Mr. Fox will always hold the first place in an assembly of the Tuilleries." "My gentleman," said Emerson, "will out-pray saints in chapel, out-general veterans in the field and outshine all courtesy in the hall. He is good company for pirates and good with academicians; so that it is useless to fortify yourself against him; he has the private entrance to all minds, and I could as easily exclude myself as him."

Good speech is a rule of manners. It always avoids exaggeration. Moderation in language and tone is the trademark of good breeding, and good breeding is after all mainly a matter of self culture. Madame de Staél valued conversation above everything, and so engaging was she in that art that a prominent lady of France said of her: "If I were Queen I should command her to talk to me every day." The man of education mixes with the right kind of people and reads good books. Books lead us into pleasant paths of culture and happiness. Read that you may avoid worry; read that too much hard thinking may not dull the edge of intelligence and sap the roots of memory; read that you may know what has been done in the world; read that you may acquire that power which comes from knowledge; read that you may learn to value the example of great men's lives; that through them you may know that the grave is not the goal of life. Montaigne had a passion for books and never traveled without them; he said that reading roused his reason and employed his judgment rather than his memory.

But of greater importance than good speech and reading, of higher value to the engineer than manners, is ability to write good English. Engineers are not given to public speaking; they pride themselves in being workers; they compare themselves with General Grant who did things. It is very true that the engineering profession is one of practical work; but no one can hope to achieve prominence in this profession who cannot write good understandable English. An engineer may not talk, but he must make reports; he must write letters; he should draw specifications and plans. To do these things properly he must command and know how to use the tools of language. Lord Bacon tells us that "reading makes a full man, conversation a ready man and writing an exact man." Engineering is an exact science; accuracy is the one column on which the whole structure is reared. To write clearly and accurately can hardly be called an accomplishment; it is really a necessity. No college course is complete, whether it be a classical, scientific, medical or law course, without a thorough training in English. No graduate is worthy to be called an educated man who does not speak and write good English. It lifts a man above the common; it makes him bigger than his business or profession; it trims the ship of knowledge and puts oil on rough places; it makes the man.

Margaret Fuller said that the object of life is to grow, and James Freeman Clarke has written a lecture upon this subject, "Man's Duty to Grow." A post-graduate course in self-culture will tend to upward growth. Such a course is open to every one. The greatest opportunities for that education which unfolds the whole nature of man are those which are opened when we close the college door behind us. Graduation only marks the beginning of education to one whose face looks forward and upward. Let us build high; "they build too low who build beneath the stars." Build so that life and strength and growth may vitalize the whole structure; build on lines that are straight; build so that every root and branch of the tree of knowledge lends support and does not add a twist to the whole; build that men may see in you not alone skill and wisdom, but honor, culture, manhood, example; study to improve self—

"For virtue only makes our bliss below,  
For all our knowledge is ourselves to know."

### Synopsis of Metallurgical and Chemical Literature.

#### Iron and Steel.

**Utilization of Waste Heat of Open-Hearth Furnaces in Boilers.**—In an article by A. Pfoser in *Stahl und Eisen*, p. 405 (March 7, 1912) it is pointed out that the temperature of flue gases of open-hearth furnaces ranges usually between 600 and 700 deg. C. (1100 and 1300 deg. F.), so that the heat lost by the flue gases is quite considerable. Mayer, in his book on open-hearth furnaces\* gives the following approximate heat balance sheet for an open-hearth furnace:

Total net efficiency .....	27 per cent
Radiation losses of furnace and regenerators....	29 per cent
Flue gas losses .....	31 per cent
Combustibles left in producer ashes.....	3 per cent
Radiation losses of producers .....	10 per cent

Total ..... 100 per cent

By utilizing the heat now lost in the flue gases the furnace efficiency could, therefore, be increased quite considerably, but at the present time no means are available to recuperate them in the furnace system. The idea of enlarging the dimensions of air and gas regenerators in order to increase the preheating effect, is impractical, since the temperature of air and gas when leaving the checkers is already as high as the temperature of the flue gases. The heat available in the flue gases must therefore be used for other purposes outside of the furnace.

If it is possible to utilize the heat in the waste gases which is rendered available by reducing the temperature from 600 or 700 deg. C. (1100 or 1300 deg. F.) down to 300 deg. C. (about 570 deg. F.), a furnace of 34 to 35 tons capacity with a coal consumption of 1350 kg (2970 lb.) coal per hour (7200 calories per kilogram or 13,000 B.t.u. per lb) is able to yield 1800 kg (3960 lb.) steam per hour at 10 atmospheres (or 147 lb. per square inch). Under the assumption of evaporating 8 lb. water per pound of coal during 300 days a year and with a coal price of \$4.00 per ton of 1000 kg or 2200 lb., the saving per year will be \$6360, or in other words, there will be a net saving of 225 kg (495 lb.) coal per hour or since the present coal consumption is 2970 lb. per hour, the net saving will be  $4950 \div 297 = 16.7$  per cent.

The heat balance of such an open-hearth furnace would now appear as follows:

Total net efficiency (27.0 + 16.7) .....	= 43.7 per cent
Radiation losses of furnaces and regenerators = 29.0 per cent	
Flue gas losses (31.0 - 16.7)..... = 14.3 per cent	
Combustibles left in producer ashes..... = 3.0 per cent	
Radiation losses of producers .....	= 10.0 per cent

Total ..... 100 per cent

\*Dr. F. Mayer, *Die Wärmetechnik, des Siemens-Martinofens*, 1908.

With a flue gas temperature of 600 to 700 deg. C (1100 to 1300 deg. F.) the pound of coal (with a calorific value of 13,000 B.t.u. per lb.) produces therefore 1.33 lb. of steam of 147 lb. gauge pressure. Some difficulties, however, have to be overcome since the furnace draft would be injured by such a boiler installation. It is important to maintain a good draft at the stack base, but with the additional frictional losses in the boiler arrangement the ordinary height of the stack of 144 ft. will not be able to overcome this. The height of the stack would have to be increased considerably, which, in most cases, would hardly be practical. The use of artificial draft, however, is quite practicable and the installation would be paid for in 1 1/2 or 2 years by the gain figured above. With artificial draft and with an economizer the waste gases can be cooled down even further to 300-400 deg. F., so gaining an additional 20 per cent steam production. The author, A. Pfoser, has already successfully put in operation such flue-gas boilers in connection with zinc and glass melting furnaces where they have given excellent results in practice, in spite of the much lower flue-gas temperatures. He concludes that for open-hearth furnaces the system would be even more profitable.

**Nickeliferous Pig Iron.**—An abstract in *Stahl und Eisen*, 1912, p. 708, gives results of two melts made by H. Thaler, one with a carbon content of 3.5-4 per cent, the other with 1.5-2 per cent carbon, the nickel varying from 0 to 48 per cent. In high-carbon iron a nickel content of 1 per cent was sufficient to separate half of the carbon as graphite; this segregation increases with the nickel content and reaches its maximum at 47.78 Ni, where 85.71 per cent C has segregated as graphite. The freezing point of the high-carbon set rose from 1122 deg. C. to 1240 deg. C., in the low-carbon series it remained at about 1350 deg. C. The perlite point, however, drops, while nickel is increased up to 6.4 per cent from 710 deg. to 550 deg. The structure of the white pig iron is considerably changed by a nickel content of only 1.08 per cent. The perlite structure is hard to notice; the carbon is segregated as graphite. This segregation increases with the content of nickel and the perlite disappears more and more. Instead of perlite fine needles of cementite appear; surrounded by troostosorbitic seams. (The original paper by Thaler was published in *Giess. Zeitung*, 1912, Feb. 1 and March 15.)

#### Gold and Silver.

**Principles of Agitation.**—In a review of the development of agitation as applied to cyanidation of slime pulps, Mr. L. C. Trent, of Los Angeles, Cal., gives some ideas on the proper method of application and quantity of compressed air which will give the best results. His article is found in the June, 1912, issue of the *Mexican Mining Journal*.

While air is indispensable to the perfect action of the cyanide process, only a limited quantity can serve a useful purpose in aiding dissolution of the precious metals, and the author is of the opinion that any excess over this amount not only does no good, but is absolutely a detriment on account of the various reactions which it brings about between the chemicals in the cyanide solution. Alkalinity is destroyed by the action of oxygen on the sulphides in the ore, and by the reaction between carbon dioxide in the air and calcium hydrate, forming calcium carbonate. Cyanide is oxidized and rendered unfit for further solution of gold and silver. The author likens the action of the air-lift agitator to a Bessemer converter, in which the great volume of air blown through the charge creates a number of chemical reactions, most of which are not useful in dissolving the precious metals, but merely cause loss of expensive chemicals. He believes, therefore, that it is quite as essential to regulate the quantity of air used in cyaniding as to regulate the use of any chemical reagent that is employed in the reaction.

Instead of applying air in large volume and allowing it to pass through the solution in large bubbles or masses, it should

be applied in a finely divided condition so that it can be retained in the mass of the pulp as long as possible. The author therefore prefers methods of mechanical agitation, in which a necessary amount of air is admitted to the solution circulating through the pump, instead of using compressed air for agitation. He claims that the latter method chills the charge by expansion of the compressed air, thus extracting heat useful in causing solution. Atomized air sent into the charge with the circulating pulp does not chill the charge because the compression essential to entering is obtained from the liquid, and the heat of compression is retained, rather increasing the temperature.

It is the opinion of the author that the science of agitation offers numerous avenues for research.

**Slime Treatment in Victoria, Australia.**—In the *Mining & Engineering Review* (Melbourne) for April 3, 1912, W. J. NICOL describes the treatment of current and accumulated slime at the Lord Nelson mine. The former assays from 24 to 40 grains per ton, and the latter averages 31 grains per ton. This gives a gold value ranging from \$1 to \$1.65 per ton for current slime, and about \$1.30 for the old material, and it is apparent that there is not a wide margin for profit after deducting operating expense and allowing for loss in tailings. The old slime is mixed with barren cyanide solution in a vortex mixer, and combined with current slime which has been dewatered as much as possible. This mixture is agitated in mechanical agitator tanks fitted with four-arm stirrers running at 7 r.p.m. There are five of these tanks of 31 tons capacity each, and three of them are filled and emptied daily. The agitated pulp is pumped to filter tanks, each containing twelve leaves 9 ft. by 5 ft., having an effective filtering area of 1080 sq. ft. These leaves are manifolded in the usual way, and connected with wet vacuum pumps. With the three-tank system of filtration the flow of slime and wash water to the tanks approximates continuous operation, and the discharge of residue is much more nearly continuous than with single tank arrangement. At any one time, one tank is filled with slime and a cake is being formed, another tank is filled with wash water and the cake is being washed, while the third is either discharging residue or waiting for another slime charge. The capacity of the filters is determined by the time required to satisfactorily wash the cake, which varies from 45 to 60 minutes. The cake averages 13 lb. dry slime per square foot of filter area, and allowing 50 minutes for washing, the capacity of the plant is about 7 tons per hour. Precipitation is by zinc shavings. The solution is strengthened immediately before precipitation as a strength of not less than 0.03 per cent KCN is found necessary for good precipitation. No figures are given as to cost of operation, but the plant had been in operation for about eight months when these notes were contributed. Operation was undertaken only after the completion of numerous tests.

#### Lead and Zinc.

**Magnetic Separation of Pyritic Blende Concentrates.**—It sometimes happens that plants erected for the treatment of ore must be altered on account of an unexpected change in the character of the ore. Such was the case at the Pierrefitte Mines, Hautes Pyrenees, France, where the original ore was argentiferous galena with blende, but which later became more and more pyritic in character. The manner in which this difficulty was overcome is described by E. C. HUGON in *Bulletin* No. 92, I. M. M. (London).

The choice of methods for separating the pyrite from the blende seemed to lie between electrostatic separation on the one hand, and either wet or dry magnetic separation on the other. The former was soon eliminated on account of the varying character of the ore and the difficulty of getting reliable data or having tests made. Samples of the ore were submitted to two firms manufacturing wet magnetic separators, and to one firm making separators working on roasted ore. The results obtained were as follows:

Process	Size	Original Ore		Zinc Concentrates		Zinc Recovery
		Zn%	Fe%	Zn%	Fe%	
Wet, No. 1	12 mesh	32.6	19.5	42.6	11.4	79.3
Wet, No. 2	20 mesh	33.7	...	41.9	...	90.2
Wet, No. 2	40 mesh	33.7	...	40.7	...	93.0
Roasted Conc	4 mm	34.5	18.4	46.4	10.0	98.0
Roasted Conc	12 mesh	34.5	18.4	45.4	9.7	97.0

Apparently the roasting process gave much better results, both as to grade of zinc concentrate produced and percentage recovery. The better enrichment by this process allowed for marketing blende containing silicious matter, thus avoiding regrinding and further treatment loss, at the same time offering the opportunity of getting a higher price per unit of zinc in the ore. The selling price per ton of zinc in blende rises rapidly with the increased percentage of zinc, while the loading and transport charges per ton of zinc is decreased materially with the higher grade of concentrate.

Accordingly a plant was installed to treat the pyritic blende product from the wet concentrator. The roasting furnaces installed are of the McDougall type, with five hearths; the cooler consists of sixteen water-jacketed tubes arranged circularly around a hollow cast-iron axle rotated by worm gearing. The inner tubes through which the ore passes are 3 in. in diameter, and the outer tubes 4 in., thus providing an annular space of 1 in. for water jacket. The cooled ore is screened and the undersize treated on a magnetic separator, making but two products, blende and pyrite concentrates. The capacity of the two furnaces is 50 tons in 24 hours; of the cooler, 40 to 50 tons, and of the separator, 70 tons.

**Flotation of Minerals.**—In our issue for August, 1911, p. 426, we reviewed the work of an Australian investigator in the principles of flotation. In the *Australian Mining Standard* for April 11, 18, 25 and May 2, 1912, the same author, KENNETH A. MICKLE, publishes a continuation of his researches in flotation.

The flotation processes which have become such a factor in concentration, particularly of zinc ores, depend for their success on differential gas and liquid attaching phenomena. The sulphides are floated by the agency of gases alone or by oily substances.

**Attachment of Gases and Liquids.**—Pure water on being agitated shows little tendency to form a froth, or, in other words to show an attachment of gas particles to itself. In order to determine an approximate measurement of the attachment of air to water and to other liquid mixtures, the author added to a given quantity of water (60 cc.) a drop of various oils and agitated the mixtures vigorously with air, noting the amount of froth produced. The following list of oils is arranged in the order of their froth producing qualities, the first giving the greatest froth; (1) saponine; (2) turpentine, phellandrene, residue from eucalyptol; (3) refined petrol, acetic acid; (4) eucalyptol, crude shale oil, cotton seed oil; (5) oleic acid, combustion engine oil; (6) shale residual oil, shale turpentine substitute, Austral machine oil; (7) kerosene; (8) alcohol, oil of wintergreen, naphtha, gasoline, petroleum ether, sulphuric ether. The opacity of these mixtures was also noted as an index of the attachment of oil and water particles. The following list gives the results of the opacity tests, the oils being arranged in the order of the intensity of opacity produced: (1) oil of wintergreen; (2) turpentine, cotton seed oil; (3) residue from eucalyptol; (4) Austral machine oil; (5) phellandrene; (6) kerosene; (7) naphtha.

In the case of the other substances a clear solution was obtained as the result.

**Absorption of Oil.**—In an effort to get some measure of the degree to which various sulphide minerals would absorb various oils, the author agitated various quantities of different ores with 200 cc. water and 5 grams of oil, both with and without 0.5 grams sulphuric acid. While it is impossible to give here the details of all the tests made, we present the author's conclusions as to the effect of oil and acid on sulphide and gangue minerals.

(1) Gangue minerals in oil and water exhibit a mild tendency toward attachment of oil and mineral in preference to the attachment of oil and water. In acidulated solutions this tendency is lessened.

(2) Sulphide minerals in oil and water absorb varying amounts of oil. Large proportions of oil tend to form magma, and smaller proportions plastic masses and coherent aggregates. The character of these oily magmas depends on the amount and character of the oil used. Thick oils give viscous, coherent products and thin oils less coherent masses. Oily magmas with considerable proportions of oil will entangle and hold gaseous bubbles with a degree of persistency which depend on the viscosity of the oil. Sulphides carrying an absorption of about 5 per cent of oil tend to attach gaseous bubbles, and this tendency increases as the proportion of oil diminishes until a certain limit is reached, which is 0.5 per cent or thereabouts. Absorption is more pronounced with sulphides than with gangue minerals. The amount of oil absorbed depends on the surface exposed.

(3) Sulphide minerals in acidulated water and oil act as above, but the adsorption of oil by the gangue minerals is decreased. The maximum amount of oil absorbed by sulphides in a stable manner when crushed to 80 mesh is in the neighborhood of 10 to 15 per cent of their weight. Such a small quantity of oil as 0.1 per cent cannot be separated from the mineral by any mechanical means, and such quantity may be regarded as through adsorption. When more oil is present it is probable that a secondary envelope becomes attached to the primary film.

**Adsorption of Gases.**—Investigation was made of gas absorption by the following experiments. Pieces of copper and silver foil were cleaned by boiling in caustic soda, washing in water and drying. Cleaned and uncleared pieces of foil were then placed in a vacuum flask in (a) ordinary distilled water, (b) air-free distilled water and (c) ordinary tap water, and subjected to reduced pressure of 26 in. mercury. In the case of the cleaned foil, a few bubbles collected on it in the distilled water, while in the tap water enough bubbles collected to float the foil. In the case of the uncleared foil enough bubbles collected on it in the ordinary distilled water and ordinary tap water to float the foil, but in the air-free distilled water very few bubbles were formed. On repeating these experiments in water to which a drop of oleic acid had been added and agitated, in all cases the cleaned and uncleared foils floated by reason of the attached gas bubbles. These experiments show that the persistence of attachment of bubbles is increased when the surface of the foil is contaminated by some oily substance.

Cleaned and dried needles would not float on the surface of freshly drawn distilled water, but when either the needles or water was allowed to stand in contact with the air for some time the needles would float.

Cleaned and uncleared pieces of iron wire were submerged in a saturated solution of carbon dioxide, with the result that the cleaned pieces collected very few bubbles on their surfaces, while the uncleared ones were shortly covered with a fine frost of bubbles and caused to float to the surface. This shows that gas attachment is enhanced by a superficial coating of oily matter.

Some Broken Hill jig tailings were cleaned with acid and distilled water and submerged in a solution of carbon dioxide. Gas bubbles collected on the sulphide mineral, but except in the case of a few pieces of garnet the gas did not collect on the gangue minerals.

The gas collected from sulphide mineral which had been separated by an oil process gave the following analysis: Nitrogen 72 per cent, oxygen 2 per cent, carbon dioxide 26 per cent. The gases collected by subjecting dry minerals to reduced pressure showed varying, but large, quantities of carbon dioxide. It was also shown that more gas was collected from the sulphide minerals than from calcite and quartz. That this gas is

not derived from the decomposition of carbonates during the experiment is shown by the negative results obtained from calcite and cerussite. There is apparently a condensation of carbon dioxide on the surface of sulphide minerals, and the fact that slime mineral shows this tendency to a greater degree than coarse grains would indicate that the phenomenon is a surface action.

### Recent Metallurgical and Chemical Patents.

**Continuous Vacuum Filter.**—In Fig. 1 we show a sectional elevation of a form of filter for cyanide pulps which has been patented by HARRY E. KIER, of Colorado Springs, Colo. It consists of an endless chain of filter sections or pallets traveling around sprocket wheels placed at the apices of an imaginary isosceles triangle. Each section is connected by a flexible tubing 23 with the circular valve which occupies a central position behind the sprocket wheel 26. This valve has one long port connecting with a vacuum pump, and one short port connecting with a source of compressed air. In operation the chain of filters moves in the direction of the arrow, and pulp is fed onto the filters from the launder 20. At this time the

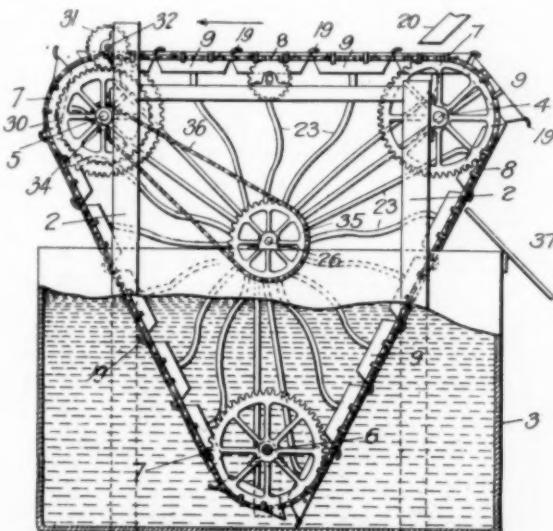


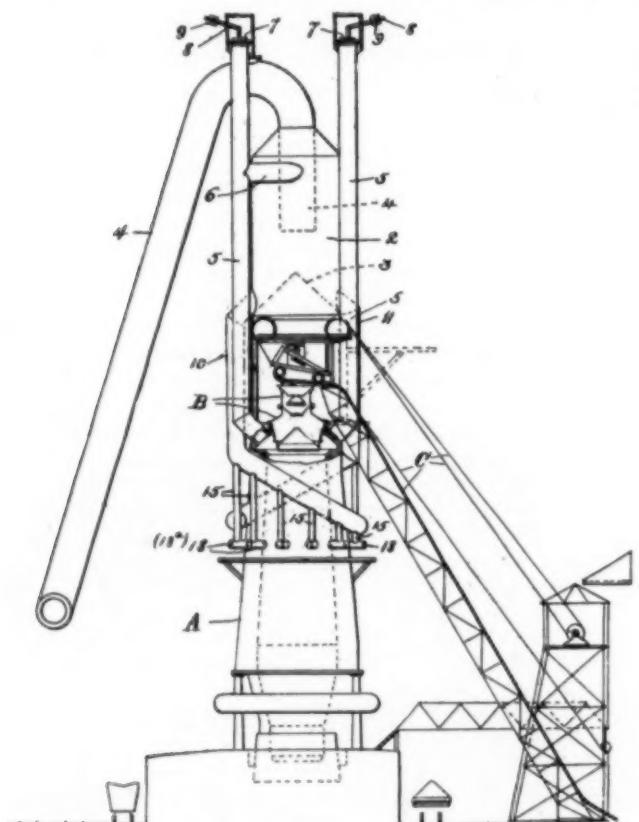
FIG. 1.—CONTINUOUS VACUUM FILTER.

valve connection is such that vacuum is applied to remove the valuable cyanide solution. This suction continues until the sections traverse the other two sides of the triangle, passing through the tank 3 containing wash water. On reaching the upper right hand sprocket the suction is cut off and compressed air applied to force the cake from the filter section, whereupon it drops off onto the deflectors 37 and falls into a suitable car. Apparently no provision is made to keep separate the pregnant solution separated from the original pulp and the washings which pass through the cake during its travel through the water tank. (1,026,917, May 21, 1912.)

### Gold and Silver.

**Precipitation by Atomized Lead and Zinc.**—In this journal, March, 1912, p. 180, was described mechanical means for producing finely divided, or "atomized" metals, such as lead and zinc. In a later issue, May, 1912, p. 305, we mentioned a patent granted on the process of atomizing. More recently another patent has been granted to James M. Neil, of Toronto, Canada, on the process of precipitating precious metals from cyanide solutions, by means of atomized metals. The inventor has discovered that when finely divided lead and zinc are added to a cyanide solution of gold and silver, these metals are precipitated more efficiently and rapidly than when zinc dust is used. In carrying out his invention, atomized lead and atomized zinc are used, in the proportion of about one part lead

to one or more parts zinc. The best method of adding the metals is to use them separately in the following manner: Cyanide solution is run into a suitable tank fitted with agitating apparatus. Atomized lead is then added to the solution in the proportion of about 100 lb. lead to 10,000 gal. cyanide solution. This mixture is then thoroughly agitated, and while



which cuts slightly into the zone of rabble No. 1, and removes from the first zone a certain amount of ore at each

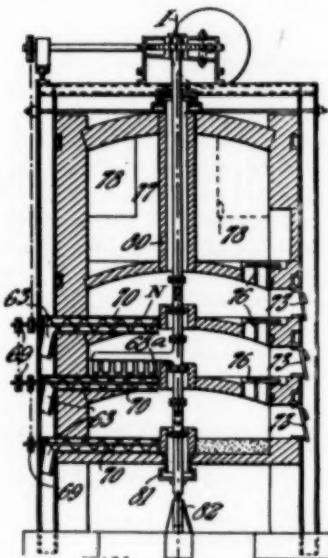


FIG. 4.—SECTIONAL END ELEVATION.  
MERTON FURNACE.

central point of discharge, from which it may be allowed to pass completely out of the furnace, or fall onto the next hearth below for further treatment, traveling in the opposite direction.

The manner of discharge is illustrated in Fig. 4, where an Archimedean screw revolving in a cast iron case is shown connected with the point of discharge. This screw may be made to deliver the ore from the furnace; or by means of perforated slides in the screw casing, the ore may be passed onto the hearth below. (1,022,961, Apr. 9, 1912.)

### Lead and Copper.

**Smelting Furnaces.**—In this journal, December, 1910, p. 671, was described the essential points of the so-called Partridge smelting furnace. A patent recently issued to the inventor, ALLEN R. PART-RIDGE, of Denver, Col., covers practically the same points as given in the foregoing reference. The principal points about the furnace are the utilization of the heat of the slag in pre-heating the air blast, and the substitution of a complete circular opening between crucible and furnace shaft in place of the usual tuyeres. Fig. 5 in the adjoining column shows the application of these points. The water-cooled furnace shaft is shown at *B'*, with the crucible *D* enclosed in a crucible box *C*. The slag flowing from the crucible falls onto a train of slag cars *K* which revolve about the central support *N*. Air enters the enclosed slag box at *T*, passes over the hot slag and rises to the crucible chamber, where it enters the stack through the narrow circular slot between crucible and shaft. (1,025,922, May 7, 1912.)

A similar device has been patented by ALFRED D. LEDUC, of Rouen, France, in which the inventor makes use of a slot between upper and lower water jackets as a continuous tuyere, preferring this arrangement to the customary individual tuyeres. (1,025,531, May 7, 1912.)

**Refining Scrap Lead.**—The treatment of old storage battery plates and waste material from lead accumulators is the subject of patent granted to JULIUS ASBECK, of Krantscheid-Westerwald, Germany. He claims that pure lead can be ob-

tained from such material by melting it at a low temperature with a flux of caustic soda and sulphur or a sulphur compound as sodium thiosulphate, sodium sulphide or sodium polysulphide. Appropriate mixtures consist of 3 parts of caustic soda to 1 part sulphur; or equal parts caustic soda and sodium thiosulphate; or 3 parts caustic soda and 1 part sodium sulphide or polysulphide. A temperature of only 400-500 deg. C, is necessary. (1,025,956, May 14, 1912.)

**Refining Copper.**—A method of refining molten copper has been devised by WALTER A. ROCKEY and HILLIARY ELDREDGE, of New York, N. Y. To carry out the process the copper is first fused and then poured into a fused bath of boron trioxide, or one containing that compound. The inventors prefer to carry out the process by causing the copper to flow downward into the flux, through the flux and upward out of the flux. During this time of contact the temperature is maintained at the required point to expel all or a majority of the occluded gases and to permit solution of the oxides by the fused boron trioxide. (1,027,760, May 28, 1912.)

**Sintering Ores**—Additional patents have been granted to ARTHUR S. DWIGHT, of New York, N. Y., in connection with his method of roasting and sintering ores for blast furnace

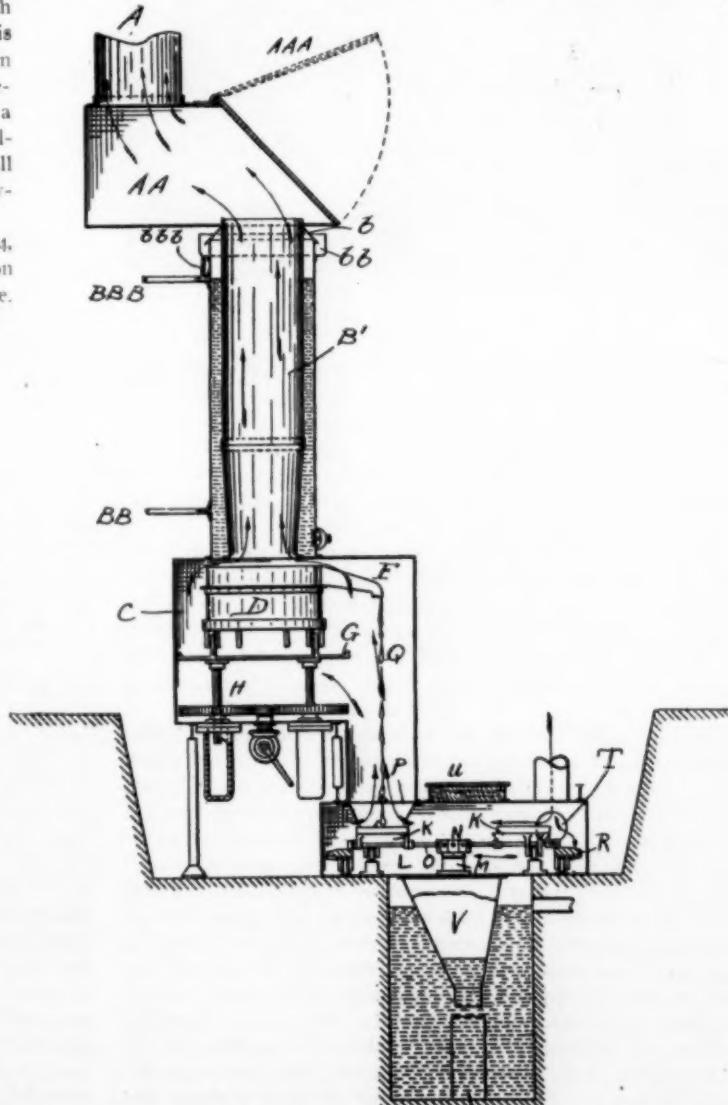


FIG. 5.—HOT-BLAST SMELTING FURNACE.

treatment. These machines have been described in this journal February, March and May, 1912, pages 87, 162 and 320, respectively. (Reissue 13,423-4, May 28, 1912, and 1,027,110, May 21, 1912.)

## The Parral Tank System of Slime Agitation.

BY BERNARD MACDONALD.

For the efficient treatment of ores amenable to cyanidation, it has been found, in the majority of cases, especially with silver ores, that the "all-slimer" method of preparation is essential. When the ore is pulped in water to a *slime* the finest particles of the gold and the silver compounds in it are liberated from the enclosing vein matter, and thus freed and

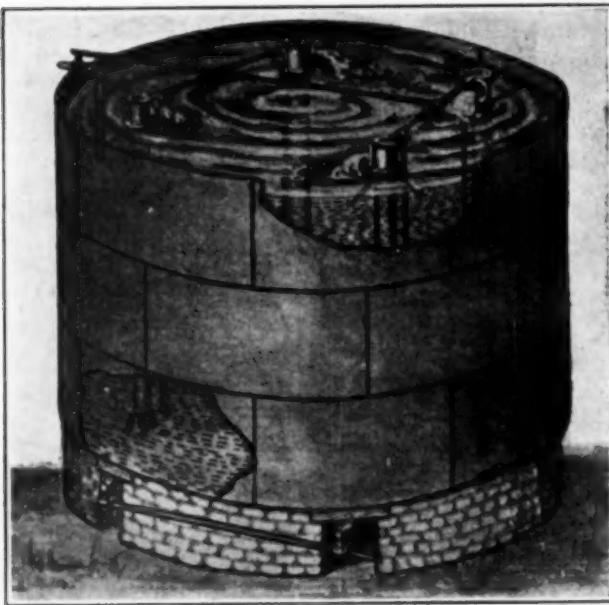


FIG. 1.—PARRAL TANK.

themselves reduced to impalpable slime, they are in the most favorable condition to be dissolved by the cyanide solution.

The cyanide solution, which is the water constituent of the slimer ore, contains dissolved in it the cyanide and other chemicals required for the treatment and is mixed with the slime in ratios ranging from 1 to 2 by weight (approximately 2½ to 5 by volume) according to requirements.

The ideal condition of the slime for treatment is to maintain its solid and solution constituents in proper proportional mixture, that is, to have each infinitely small particle of the solids surrounded by 2½ to 5 times its own volume of solution at all times during the treatment period, incidentally giving it such free contact with the air that it may absorb the amount of oxygen required for the chemical reactions.

The operation by which this condition is maintained is called "agitation" and is carried on in tanks which contain the pulp. Tanks have no other function in a cyanide plant than to serve as economical and convenient containers or receptacles for holding the pulp, solution or water used in plant operation and they may be built of wood, steel or concrete and be of such shape or size as may be suitable for the quantity of pulp to be treated daily or the method of agitation employed.

Various methods or systems have been designed for agitation, and these may be installed and operated at various costs and degrees of efficiency and economy. In a paper read at the San Francisco meeting, October, 1911, of the American Institute of Mining Engineers, which now appears in the *Transactions* of the Institute, I have described the characteristic features of the more prominent of these systems, and therefore it is not necessary to repeat what has been said there in this respect.

The object of all the systems of agitation is, of course, to maintain the solid and solution constituents of the pulp undergoing treatment in proper proportional mixture, providing at the same time the aeration necessary for the chemical reactions.

The more efficiently and economically this object can be obtained by any system the higher that system will rank commercially.

### The Parral Tank System.

During the past eight years the writer has been almost exclusively occupied in the design and construction of cyanide plants in Mexico, and a considerable portion of this time has been devoted to the design and development of a system of slime agitation in which the defects of other systems would be eliminated and which would effect the object of agitation more efficiently and economically. The result has been the Parral tank system which I have installed in several plants in Mexico, where it has been in successful operation and has proved to be superior to any other system in the following particulars:

1. It costs less for construction by 60 per cent.
2. It is more economical in operation, using only about one-third the horse power.
3. It requires neither repairs nor renewals in plants, using it for the past 14 months.
4. It maintains the pulp constituents in proper proportional mixture during the treatment period.
5. It obtains a higher extraction of the values.

In elaboration of these characteristic features it may be said in order with respect to them:

1. That the comparative low cost of construction is due to the fact that the apparatus of the system will operate efficiently in tanks of any diameter and any height, leaving to be chosen such shape of tank as will have the greatest holding capacity

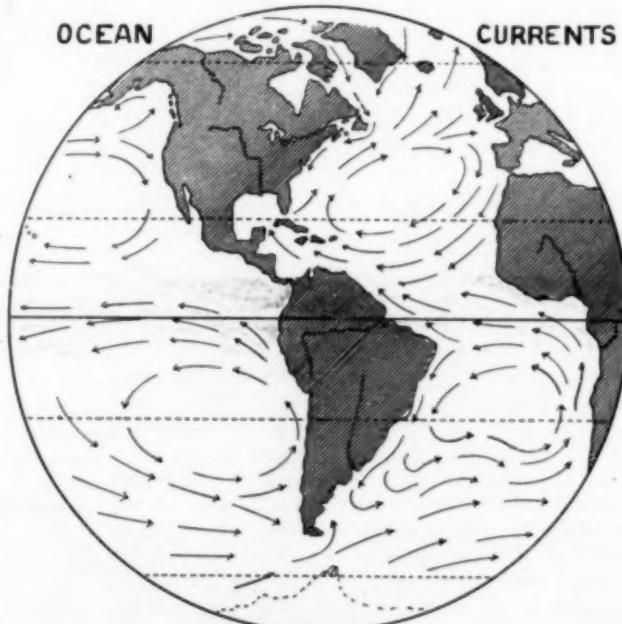


FIG. 2.—COMPARISON WITH OCEAN CURRENTS.

per pound of steel or material of which it may be constructed. Thus, in tanks for this system of approximately the same holding capacity as the standard tank of the Pachuca tank system, 157 lbs. of steel will be required for each ton of 2:1 pulp, whereas in the Pachuca standard tank 400 lb. are required. In other words, the cost of the raw material, freight and erection, is only about 40 per cent. of that for the Pachuca tank used for the same purpose. The same ratio holds with respect to other systems, which, like the Pachuca tank, require a tall, narrow shape of tank for their method of operation.

2. On account of the comparative low height of the Parral tank and the rotary flow which the plurality of transfer pipes peculiar to the system sets up in the tank-charge, only about one-third the horse power that is required for the Pachuca

tank is required for its operation. Other systems of agitation, which, in operation, require the settlement of the solids in the pulp to the bottom of the tank and draw the clear solution from the top of the tank and to effect agitation, force the clarified solution into the settled solids at the bottom, are operated at variance to the fundamental principles of agitation, and their high consumption of horse power and frequent renewals of parts are uneconomical.

3. In the Parral tank system of agitation there are no wearing parts except the air nozzle ball valve which has been in operation continuously for 14 months without showing any signs of wear or loss of efficiency, and, while these valves will naturally wear out some time, they may last several years. Side by side in the same plant there was used the rubber sleeve which protects the air nozzle in the Pachuca tank; this wore out in six weeks and in the meantime gave no end of trouble in starting up after the air was shut off for any reason, while the ball valve would start promptly without trouble under the same conditions.

4. In the Parral tank system the agitation is effected by a plurality of transfer pipes of comparatively small diameter

colloidal agglomerations and causes the friction of the solids *inter se* or in the revolving flow of the solution.

Fig. 1 illustrates a tank equipped with the apparatus of this system and how the rotary flow is created and maintained by the spouting of the transfer pipes raised a few inches above the surface of the tank charge.

It is difficult to comprehend how the discharge force of the pulp from the transfer pipes with a few inches of fall is sufficient to keep the entire charge revolving within the tank and prevent dead accumulations of the solids on the bottom.

But the fact is that it does. Indicating the sensitiveness of water to slight force, we have examples in the great ocean currents which, generated by the trade winds, revolve continuously between the shores of continents thousands of miles apart.

Fig. 2 shows the path of the Gulf stream in the North Atlantic, which is said to sweep the coral rocks on the sea bottom between Florida and Cuba as clean as a floor. Such is the effect of the rotary flow in the Parral tank system; there is no accumulation of solids on the bottom of the tank, and the solid and solution constituents of the pulp are kept in the

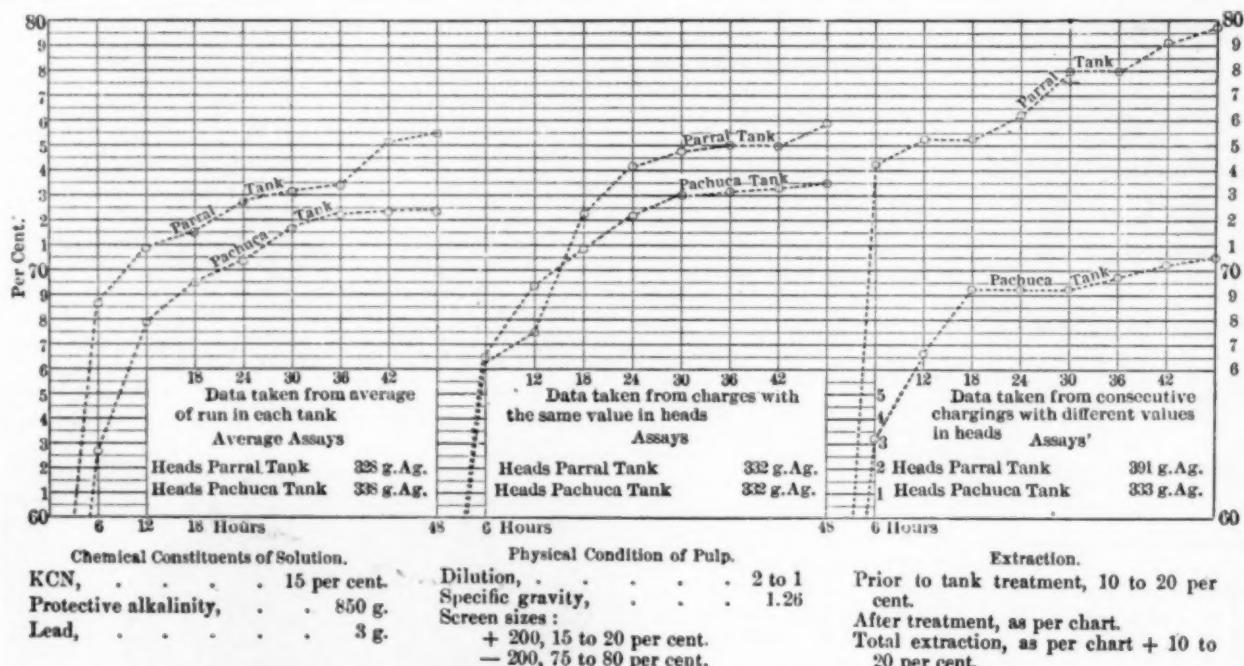


FIG. 3.—EXTRACTION-CURVES PLOTTED FROM RECORDS OF OPERATIONS IN PACHUCA AND PARRAL TANKS.

through which the continuous transfer of the pulp from the bottom to the top of the tank is brought about by compressed air. The discharged ends of the transfer pipes are horizontal and so directed that the discharging pulp will spout in the same direction with respect to the interior side of the tank and in line with segment cords thereto. This method of discharge sets up a rotary current in the tank charge which flows round and round within the tank and keeps the whole charge in rotary motion from top to bottom of the tank. This rotary flow is one of the important features of the system, as it carries the heavier pulp particles in suspension in the solution and breaks up the colloidal agglomerations in the slime. In other systems of agitation, except that using stirring arms, the solid particles settle vertically out of the solution, and, of course, when separated from the solution, they escape reaction with the chemicals dissolved in it.

5. In the same plant under identical conditions the Parral tank system showed a three per cent. higher extraction of values than the Pachuca tank. This I attribute to the rotary motion in the charge which maintains the solids and solution in proper proportional mixture, effects the breaking up of the

proper proportional mixture, while the spouting of the pulp at the surface of the charge gives the aeration required for the chemical reactions.

In addition to the points of superiority of the Parral tank system over others briefly referred to above, is the fact that the comparative low height of the tank practically removes the necessity for the elevating or pumping of the pulp into the tank, consequently the cost of elevators or pumps and their operation is done away with entirely or reduced to a minimum, and the pressure of the compressed air required for the operation of the transfer pipes is correspondingly lowered.

Fig. 3 is a reproduction of a diagram from the San Francisco paper, delivered before the American Institute of Mining Engineers above referred to.

It gives extraction curves plotted from records of operations in Pachuca and Parral tanks, samples taken every six hours and analyzed.

In explanation of the percentage column of the above chart, it may be said that more than 62 per cent of the head-values were extracted during the first six hours' agitation.

*South Pasadena, Cal.*

### A Centrifugal Gaswasher.

**Purification and Cooling of Blast-Furnace and Producer Gases—Recovery of Metal Dust from Gases of Lead and Copper Smelting Plants—Extraction of Tar from Coke Gases.**

BY WALTHER FELD.

In another article published in this issue my new process is described for the direct production of ammonium sulphate from ammonia and hydrogen sulphide in coal gas without the use of sulphuric acid. Mention is made there of the Feld centrifugal

washer by means of which the ammonia and hydrogen sulphide are washed out of the coal gas, but which is in general and successful use for any and every purpose in the treatment of gases or vapors with liquids. With the advantages of high efficiency due to the most intimate mixing of gas and washing liquid, and of low water consumption, the Feld gas washer combines such a high degree of simplicity and robustness of construction that it requires practically no repair and that clogging is practically impossible.

Twelve of these centrifugal washers with an aggregate capacity of 8,627,500 cubic meters (305,000,000 cubic feet) of gas per day are now in successful use for dust removal and cooling of gases; sixteen washers with 3,900,000 cubic meters (138,000,000 cubic feet) daily capacity are in use for washing out tar; three washers with 480,000 cubic meters (17,000,000 cubic feet) daily capacity for washing out naphthalene; three washers

with 420,000 cubic meters (15,000,000 cu. ft.) daily capacity for washing out cyanogen; eighteen washers with 4,695,000 cubic meters (166,000,000 cubic feet) daily capacity for washing out ammonia; nine washers with 1,050,000 cubic meters (37,000,000 cubic feet) daily capacity for washing out simultaneously ammonia and hydrogen sulphide according to the process sketched above; three washers of 420,000 cubic meters (15,000,000 cubic feet) daily capacity for washing out benzene, and seven washers of 840,000 cubic meters (30,000,000 cubic feet) daily capacity for fractional lignite distillation.

The washer which is shown diagrammatically in Fig. 1 is constructed on the centrifugal principle, and is composed of a set of chambers (Fig. 2)—say, three to six, according to the desired gas-treating capacity—placed one above the other. There is a central shaft, running on ball-bearings at the top of the apparatus, which shaft revolves at the rate of about 120 revolutions per minute. In each of the chambers there is a set of cones, each set consisting of three to six attached to the vertical shaft by means of a cast-iron hub. The lower ends

of the cones dip into the dish-shaped channel below, which contains the water or other liquid.

Through the rotation of the shaft the water is drawn up on the inside of the cones, and is thrown off at a tangent at the upper edge across the open space against the wall of the chamber. A thick body of mist, so thick that it presents a foam-like appearance, is thrown off from the tops of the cones at great velocity, and circulating in its fall with immense rapidity through the general impellent forces at work within the washer. The thought arises that the passage through successive thick seething sprays of this kind might have detrimental effect on the gas pressure; but, as a matter of fact, the

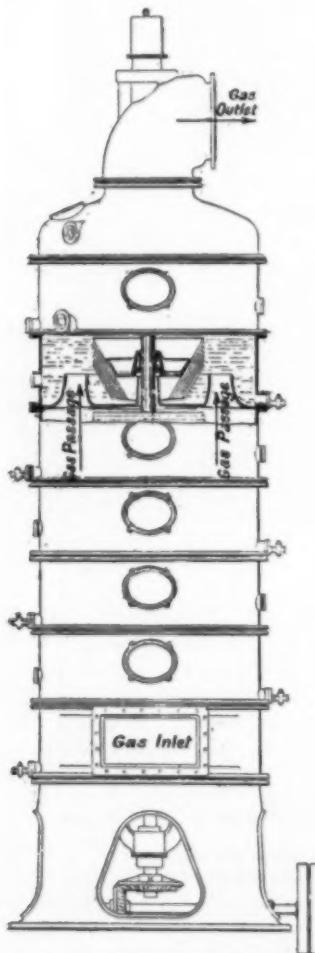


FIG. 1.—CENTRIFUGAL WASHER.

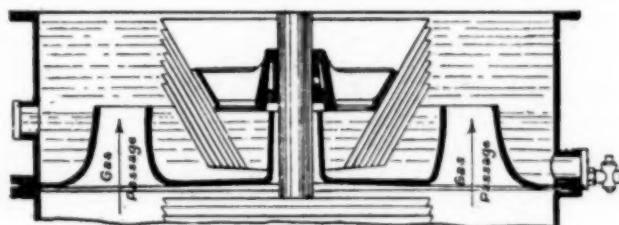


FIG. 2.—ENLARGED VIEW OF ONE OF THE CHAMBERS.

gas is sucked up and carried upwards by the whirling motion in such manner that the loss of pressure is surprisingly small.

The dish-shaped liquid container in which the sets of cones dip is provided, as stated above, with four gas-ways, which allow the gas to escape through the finely-sprayed liquid. The supply of water enters at the top, and the gas passes upwards from chamber to chamber, their courses thus being in opposite directions. The outflow of the liquid from the washer is regulated entirely by the inflow, plus what is taken from the gas. From this it will be seen that any concentration of liquor can be worked to by simply controlling the admission of the water and using the content of the washer over and over again.

The washer can be employed equally well with turbid liquids as with clear ones, and through the constant and rapid

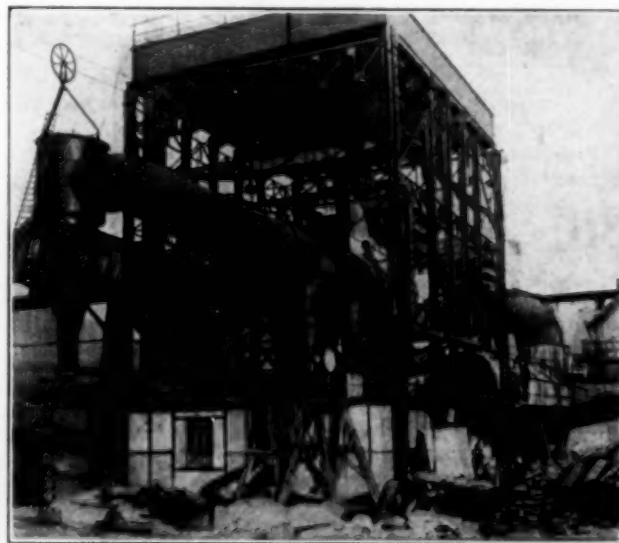


FIG. 3.—FELD CENTRIFUGAL GAS WASHER PLANT AT POMPEY STEEL WORKS.

rotation there can be no sedimentation. The washing liquid passes down from chamber to chamber; and the bottom of the apparatus is so devised that no settling can take place there. All of the liquid contents passes away at the bottom, and the gas, as mentioned, at the top.

The power required to drive the washer is very moderate. The smallest size washer, capable of treating about  $\frac{1}{4}$  million

cubic feet of gas per twenty-four hours, can be driven by  $\frac{1}{2}$  horse-power, and so on up to the largest size, capable of dealing with 45 millions cubic feet a day, for which not more than 25 horse-power is needed. The washer can be driven by belt from a small steam or gas engine, or where there is an electric generating plant on the works by an electric motor.

#### Treatment of Blast-Furnace Gases.

The purification and cooling of blast-furnace gases gets more and more important in view of their high value for power production in gas engines. In Germany and France there is hardly a steel plant which does not use the surplus of gas for this purpose, thus deriving from these gases, which formerly

the gases by passing one washer. The gases are supplied to the washers at the high temperature with which they come from the furnaces and the cooling is completed down to a temperature not higher than  $5^{\circ}$  C. above the temperature of the cooling water. The consumption of water is less than 20 per cent above the amount theoretically necessary.

The back pressure of the gases in the washer is lower than 50 mm. and therefore the consumption of power is very low. All three washers do not require more power than 60 hp.

#### Recovery of Metallic Dust from Lead and Copper Smelting Furnaces.

The recovery of metallic dust from gases of lead and copper smelting plants is accomplished by similar plant. In most of these works the fumes from the smelting furnaces are passed through chambers and long flues before they go to the chimney. In these chambers about 70 to 80 per cent of the metallic dust is separated from the gases, while the rest passes with the chimney gases into the atmosphere. There is no necessity to refer here further to the endless troubles which have arisen on this account, resulting in court injunctions of farmers against smelters, while the periodical cleaning of the dust chambers is a great danger to the health of the workmen.

On a daily consumption of 50 tons of lead, about 1,000,000 cubic meters (or 35,000,000 cubic feet) of gas are produced with about 8 grams of lead per cubic meter (or  $\frac{1}{2}$  lb. per 1000 cubic feet). The volume of the waste gases increases in the chambers and flues, by leakage through the brickwork, to about 2,000,000 cubic meters (or 71,000,000 cubic feet), and these gases, leaving the chimney, contain up to 1 gram of lead per cubic meter (or 1 ounce per 1000 cubic feet). The total loss may be estimated to be about 2 tons of lead per day.

Tests with the Feld washer on a big scale have proved that, in erecting a Feld washer immediately behind the ovens, before the gases enter the flues, more than 99 per cent of the metallic dust can be immediately recovered in form of a wet cake, containing about 70 per cent of lead. Thus the storing of and the dangerous work with the dust, and all periodical cleaning up is avoided. The value of the lead additionally recovered is about \$100 per day, against about a cost of \$50 per day for the operation of the Feld plant, including depreciation of plant and repairs.

The profit, in applying the Feld process to copper smelting works, will, of course, be considerably higher.

The treatment of the gases is the same as in the purification of blast-furnace gases, but, as it is not necessary to cool the gases, the water for purification can be used over and over again, and thus no waste water, containing free acids extracted from the gases, is obtained.

#### Tar Extraction.

For tar extraction from coal gas and producer gas the washer is equally in use with very satisfying results. More than 15 tar washers are now in operation. The following figures are obtained in a coke works at Monceau in Belgium, in treating the gases with a Feld washer at temperatures as high as  $60^{\circ}$  and  $90^{\circ}$  C.:

Temperature of the Gas.		60° C.
Tar entering washer.....	.....	23.03 grams per cu. meter. =1.44 lb. per 1000 cu. ft.
Tar leaving washer.....	.....	0.1 gram per cu. meter. =0.1 ounce per 1000 cu. ft.
Percentage of tar recovered in washer..	.....	99.6 per cent.

		90° C.
Tar entering washer.....	.....	30.04 grams per cu. meter. =1.88 lb. per 1000 cu. ft.
Tar leaving washer.....	.....	0.2 grams per cu. meter. =0.2 ounces per 1000 cu. ft.
Percentage of tar recovered in washer..	.....	99.4 per cent.

This plant treats about 75,000 cubic meters (2,600,000 cubic feet) of gas per day and has been in continuous operation for the past eighteen months without requiring any cleaning of the apparatus.

The Feld washer is built by Walther Feld, Gasabteilung, in Linz am Rhein, Germany.

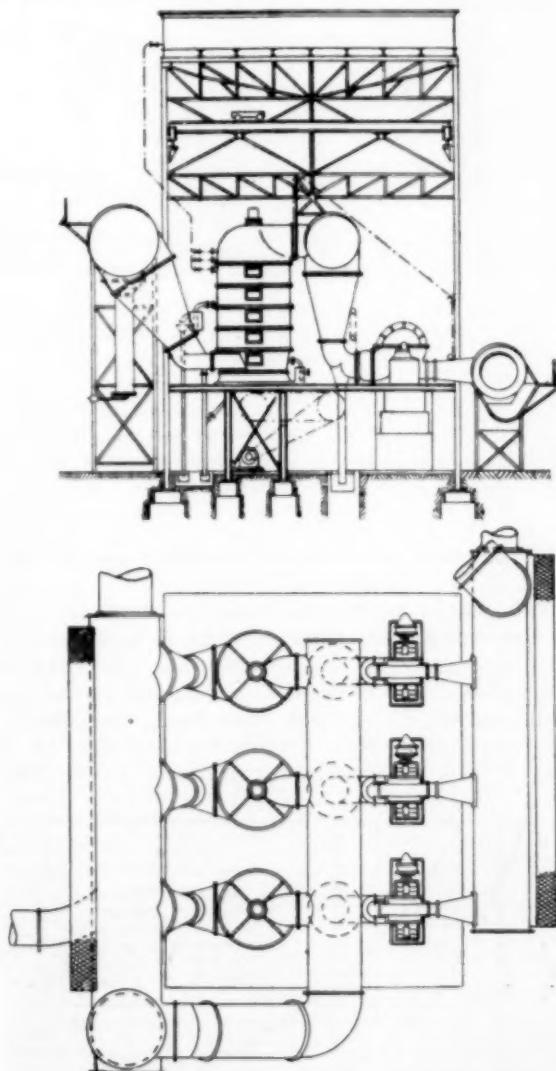


FIG. 4.—ARRANGEMENT OF THREE CENTRIFUGAL GASWASHERS.

went partially to waste, spoiling the surrounding atmosphere with their sinister fumes, an important additional profit. For this purpose the gases must be thoroughly purified from the dust contained therein and cooled.

Fig. 4 shows a Feld plant for the purification and cooling of  $\frac{1}{2}$  million cubic meters (or 125 million cubic feet) of blast-furnace gas per day. This plant was started two years ago and has since been in continuous operation in the steelworks of Pompey, France. No repairs and no cleaning of the apparatus has been required in this period. Three parallel erected Feld washers are in operation, each with a maximum capacity of 1,250,000 cbm. per day (44,000,000 cubic feet per day).

The purification and cooling is done in the same apparatus. More than 97 per cent of the dust, etc., are extracted from

### New Armored Stoneware Vessel.

BY PERCY C. KINGSBURY.

In many industries the need has been felt for a vessel of large capacity that is unaffected by acids or other materials it may contain, and that can also be subjected to a considerable range of temperature without damage. Copper or iron vessels employed to meet these conditions are often an unsatisfactory makeshift for the lack of something better. Where the corrosion is rapid, the walls of the vessel have to be made exceptionally thick and often where the action on the metal is not enough seriously to affect the life of the apparatus, the slight corrosion may impair the quality or purity of the product.

For work on a small scale, chemical stoneware has obvious advantages but this valuable material has its limitations as vessels of a larger capacity than 150 to 250 gallons cannot safely be subjected to sudden variations in temperature.

A solution of the problem is offered by the German-American Stoneware Works, of 50 Church Street, New York City, who have recently introduced a novel form of vessel that has found extensive application in Europe.

A cylindrical jacket having a rounded bottom, all of sheet iron is held together by cast-iron



ARMORED STONEWARE VESSEL.

flanges so designed that by tightening up the bolts the whole is drawn together in a perfectly uniform manner. Into this jacket is built a lining of chemical stoneware tiles, each tile being carefully ground on all four edges so as to make a perfect joint with those adjacent to it. A special acid-proof cement forms a backing into which the tiles are laid and serves to take up the difference in the co-efficient of expansion of the two materials. When all the plates are in position and while the cement is soft, the flanges are drawn together placing the lining under strong and even compression and completely closing all the joints.

It is obvious that this method lends itself readily to the construction of vessels of very large capacity. The possibility of corrosion is completely eliminated, the vessels being internally for all practical purposes one homogeneous piece of stoneware with, however, one important difference. A large stoneware vessel to resist sudden changes in temperature cannot be highly vitrified and the acid-proof quality of such vessels is, therefore, largely dependent on the glaze, but in these armored vessels the plates forming the lining can be made as hard and dense as possible without risk or fracture from rapid expansion or contraction.

A frequent source of expense and danger eliminated by the new construction is the fragile nature of stoneware. Crystals may be chipped away from the walls of these armored vessels without risk and they cannot be damaged by the most careless treatment. The stoneware tiles are made from an iron-free

clay, giving to the interior of the vessel a white glazed surface. The contents may be heated by the injection of steam or hot air or by heating coils. Connections can be made through the side or bottom of the vessel as desired. They are now made in nine standard sizes, varying from 130 to 2650 gallons

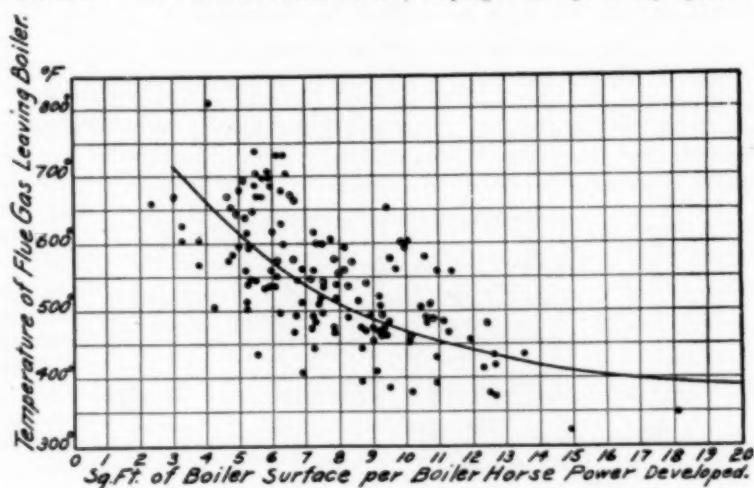


FIG. 1.—CHART SHOWING FLUE GAS TEMPERATURES CORRESPONDING TO DIFFERENT RATES OF DRIVING BOILER HEATING SURFACE. EACH POINT REPRESENTS AN INDIVIDUAL TEST.

capacity but can be supplied to special dimensions if required.

The vessels have a wide application, but their advantages should appeal particularly to dyeworks, and those interested in the manufacture of certain organic acids.

### Heat Transmission Through Conducting Surfaces

#### The Rationale of the Present Tendency of Reducing the Heat-Conducting Surface per H. P. in Boilers.

The cost of generating steam consists of two main elements, one the expense for fuel, and the other the expense for interest, depreciation, labor and other fixed charges upon the boiler, boiler setting, grate, draft apparatus, and fittings. If the amount of boiler surface employed to develop a boiler horse-

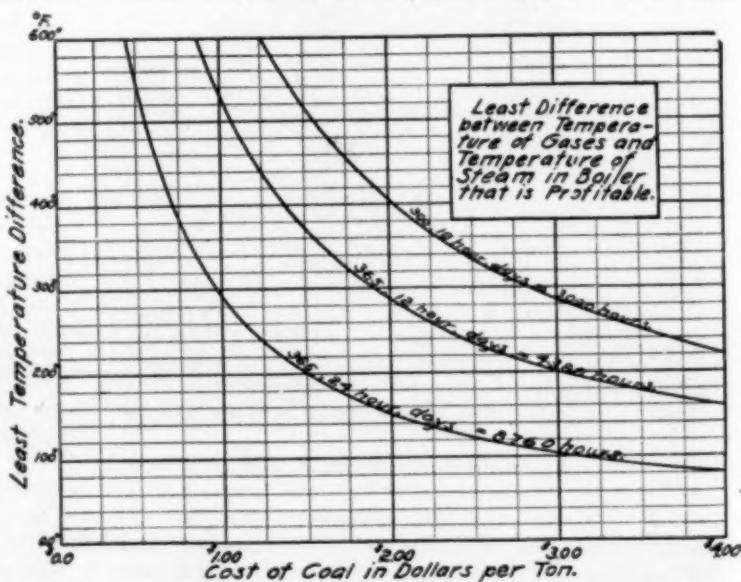


FIG. 2.—CHART SHOWING POINT AT WHICH BOILER SURFACE CEASES TO PAY PROFITS FOR DIFFERENT CONDITIONS.

power, that is to evaporate 30 lb. of steam per hour, be increased, the amount of heat recovered from each pound of

fuel will, within the limits of ordinary operation, also increase. That is, more heat will be absorbed, and the gases will be discharged to the stack and to atmosphere at a lower temperature as shown graphically in Fig. 1.

At the same time, however, that the cost of steam is being reduced by increasing the efficiency of heat absorption, the

is a use for this heat, viz.: in warming up the cold water which is to be fed to the boiler. This water may have an initial temperature of anywhere from 50 deg. or 60 deg. F., in case the water is taken from a well or stream, up to 200 deg. or 210 deg. F., in the case of returns from heating and drying coils or water heated in an exhaust steam feed water heater. Taking

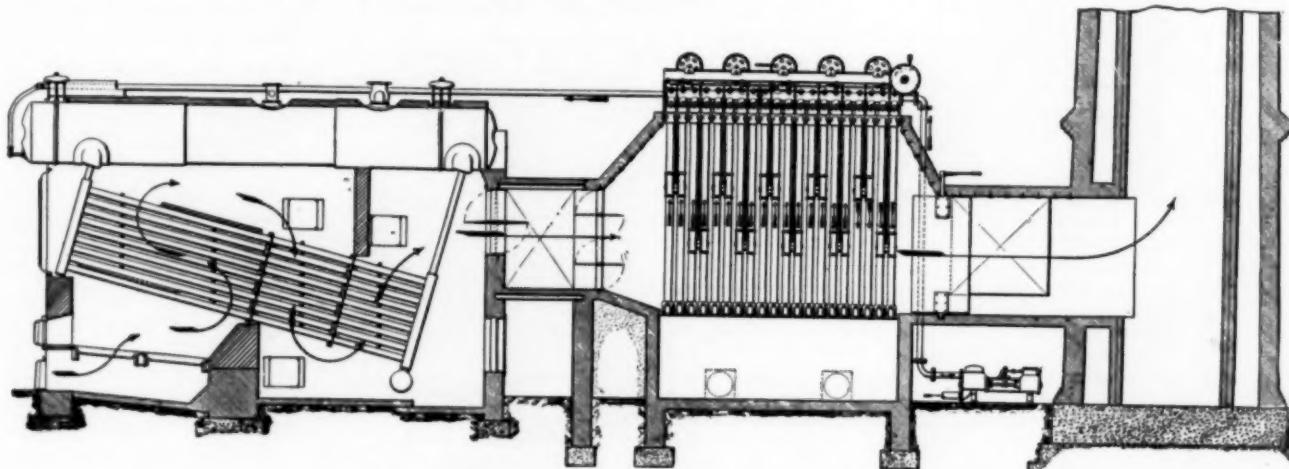


FIG. 3.—THE COUNTER CURRENT PRINCIPLE IN STEAM GENERATION AS EXEMPLIFIED BY GREEN'S ECONOMIZER INSTALLED IN CONNECTION WITH A WATER-TUBE BOILER. THE COAL GASES SERVE TO HEAT THE COLD WATER, WHILE THE HEATED WATER ABSORBS HEAT FROM THE HOTTEST GASES.

element of cost due to the fixed charges on the boiler and its appurtenances is rising. The rate at which heat is absorbed by any element of the boiler surface depends directly upon the difference between the temperature of the contents of the boiler, and the temperature of the gases of combustion in contact with that part of the boiler. If the amount of heat absorbed by that particular part of the boiler is worth more than the fixed charges corresponding, that particular element of heating surface is paying for itself, but as the temperature of the gases falls and approaches the temperature of the steam and water within the boiler, a point must soon be reached where the heat absorbed will no longer pay the fixed charges upon additional boiler surface.

Just where this limit is will, of course, depend upon the price of fuel, the charges upon boiler surface and the proportion of the whole time that the boiler surface is being used. Referring to Fig. 2, it will be seen that for plants operating 10 hours per day, 300 days per year, and using \$3.00 coal, the limit is reached when the gases are reduced to a temperature 285 deg. F., above the temperature of the steam.

If we assume steam at 150 lb. pressure gauge, which corresponds to a temperature of 366 deg. F., it will be seen that the lowest temperature to which it will pay to reduce the flue gases under the above conditions is 650 deg. F., showing by reference to Fig. 1 that it will not pay to put in more than 4 or 5 sq. ft. of boiler heating surface per boiler horsepower developed.

However, as is at once apparent, considerable heat would be wasted under these conditions. If we assume a coal containing 14,000 b.t.u.'s per pound, burned with 26 lb. of air per pound of coal, and the boiler room temperature at 70 deg. F., the temperature in the fire will be about 2230 deg. F., and if the same gases of combustion are discharged at 650 approximately 27 per cent of the total heat of the fuel will be lost in the chimney gases.

If there were no body colder than the water and steam within the boiler by which the heat from these gases might be taken up, this loss would be inevitable, but fortunately, there

water at 200 deg. F., for instance, it will be seen that between such water and flue gases at a temperature of 650 deg. F. there is a difference of 450 deg., under which conditions the provision of additional heating surface would again become profitable.

If the water, however, be sent directly into the boiler, it is at once heated up to the boiler temperature by the steam and water already there, and has no opportunity to perform the service of absorbing heat economically from gases of combustion. The remedy, obviously, is to divide the process of steam

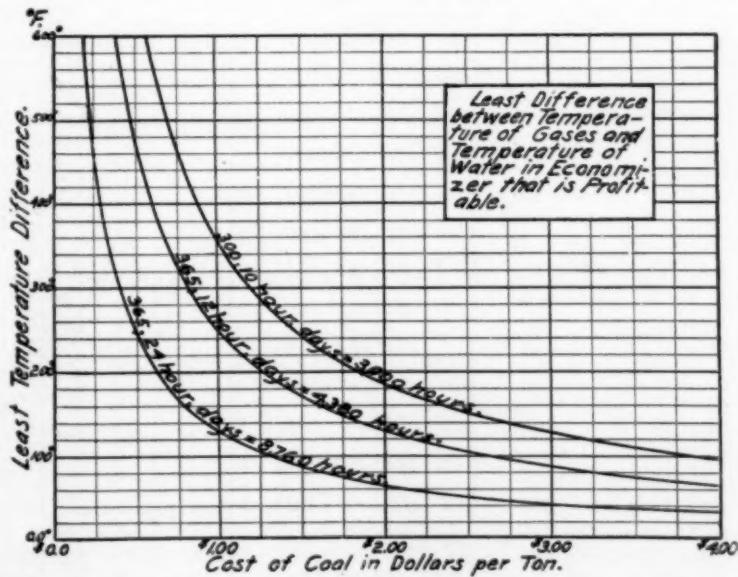


FIG. 4.—CHART SHOWING POINT WHERE ECONOMIZER SURFACE CEASES TO PAY DIVIDENDS FOR VARIOUS CONDITIONS.

generation into two parts, one of which consists of heating the water up to the boiling point, and the other the evaporation of boiling of the water; that is, to apply the counter-current principle, which has proved most economical in heat transferring apparatus of all kinds.

The apparatus in which the feed water is heated is ordinarily

called an economizer, and the boiler and economizer, connected as shown in Fig. 3, become in effect a counter-current appar-

deg. F. If 6 to 7 ft. of boiler surface be installed, as is usual in recent practice, the gases will leave the boiler at 550 deg. F.,

and if the water enter the economizer at 110 deg. F., as from the hot well of a surface condenser, 3 to  $3\frac{1}{2}$  sq. ft. of economizer surface will suffice to heat it to 290 deg. F. at the point where it enters the boiler, saving 14.6 per cent of fuel. As shown by the dotted lines, however, it would be possible to curtail the boiler surface to between 4 and 5 sq. ft. per boiler horsepower, leaving the gases at 700 deg. F. at the point where they leave the boiler and enter the economizer, and with these hot gases, 6 or 7 sq. ft. of economizer surface would suffice to give the same final gas temperature as before and maintaining the same efficiency of heat absorption. In other words, approximately 1 sq. ft. of economizer surface would replace 2 sq. ft. of boiler surface without impairing economy, and since economizer surface is cheaper than boiler surface per square foot, this change would re-

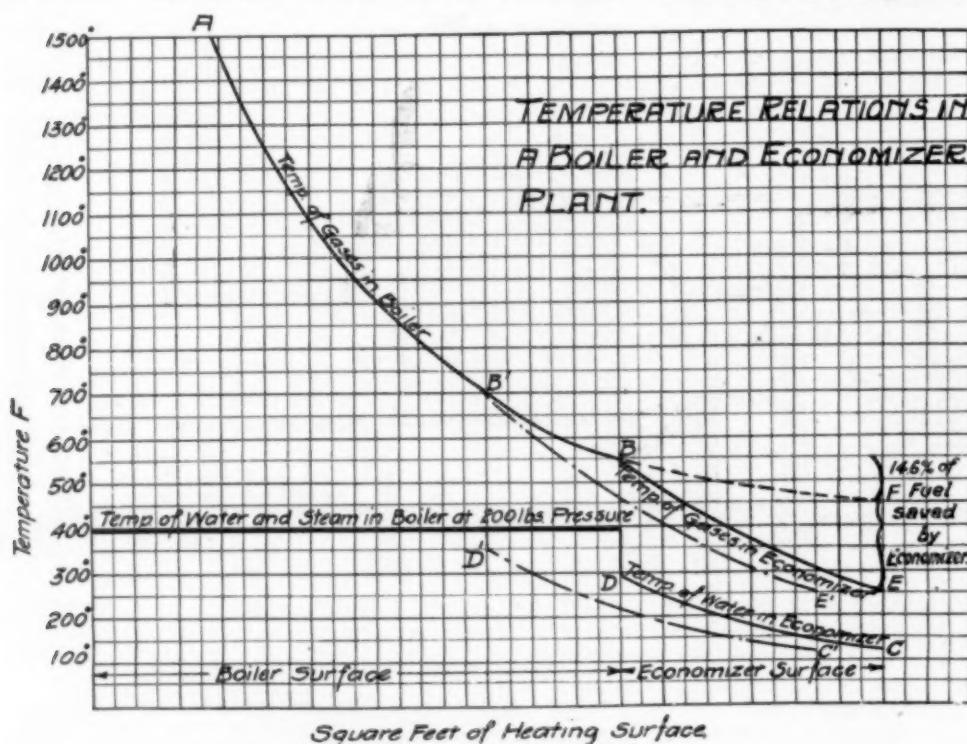


FIG. 5.—CHART SHOWING RELATIONS BETWEEN TEMPERATURES OF GASES AND WATER AND STEAM IN A BOILER AND ECONOMIZER INSTALLATION.

atus for the transfer of heat from hot gases of combustion to water which is to be turned into steam. The economizer costs somewhat less than the boiler per square foot of heating surface, and the temperature difference at which it ceases to be profitable is therefore lower, as will be noted from Fig. 4.

As an example, suppose that fuel costs \$3 per ton and the plant is operated 300 days per year and 10 hours per day. It will be seen that the lowest economical temperature difference is about 110 deg. F. If the initial temperature of the water entering the economizer is 200 deg., as just assumed, this will give as a final temperature to the flue gases 310 deg. F., which is still hot enough to produce sufficient draft with a good chimney.

The temperature relations within the boiler and economizer are indicated in

sult in a considerable overall saving in fixed charges.

In the design of large steam power plants, such as central stations for electric light and power in the large cities, power

Savings per 8760 hrs. per Sq. Ft. of Econ. Surface.

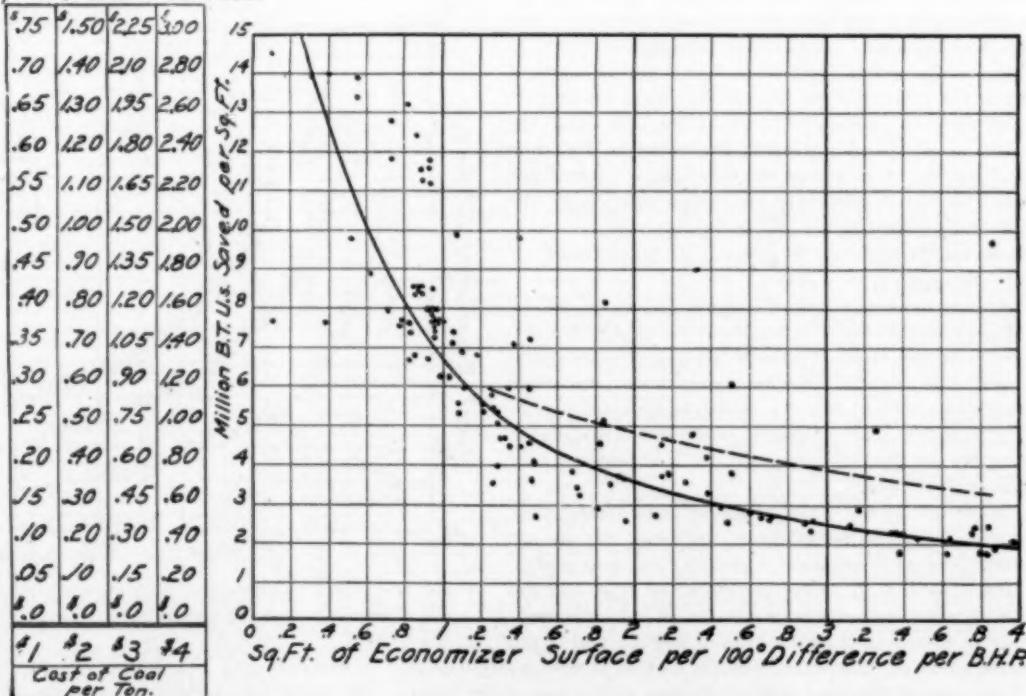


FIG. 6.—HEAT AND MONEY SAVED EACH YEAR BY 1 SQ. FT. OF ECONOMIZER SURFACE.

Fig. 5. It has been here assumed that the boiler is operated at 200 lb. gage pressure, giving a steam temperature of 388

stations for electric traction systems, etc., this principle has been recognized and is being applied; that is, the boiler sur-

face is being considerably curtailed, while the efficiency of heat absorption is maintained or even improved by substituting the cheaper and more effective economizer surface.

In addition, there are other causes leading to the increased adoption of economizers. For one thing, there is a tendency toward higher and higher pressures, 200 lb. per square inch being not uncommon in steam turbine plants. As will be evident

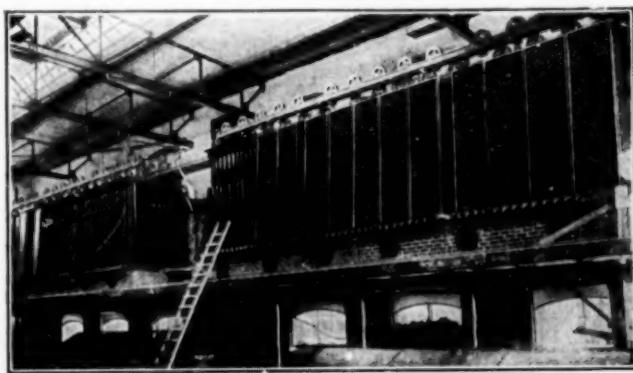


FIG. 7.—GREEN'S ECONOMIZERS INSTALLED IN POWER PLANT OF DAN RIVER POWER & MANUFACTURING COMPANY.

from the preceding arguments, any increase in the steam pressure, with accompanying increase in the boiler temperature, renders boiler surface correspondingly less efficient in the absorption of heat from the gases of combustion, since it reduces the available heat "head" causing the flow of heat from the gases to the water or steam. This leaves a greater duty to be performed by the economizer, and makes the latter correspondingly more profitable.

Another factor working in favor of the economizer is the greater efficiency obtainable from auxiliary apparatus, such as boiler feed pumps, circulating pumps, fan engines, stoker engines, etc. The less the steam consumed by these appliances, the less exhaust there is available to heat the feed water in exhaust heaters, so that instead of obtaining 200 deg. or even 210 deg. F. with some exhaust to waste, it is not uncommon to find plants in which there is difficulty in maintaining a temperature of 160 deg. F. in the water leaving the heater. Naturally the colder the water entering the economizer, the greater will be the activity of the surface in transmitting heat from the gases.

Another factor of special importance in many plants is the large heat and water storage capacity of the economizer, giving it the ability to deliver large quantities of hot water in a short time, as when water is drawn from the boilers for filling dye and wash tubs, or when excessive drafts are made for steam for any purpose. While in the latter case the economizer does not supply the steam directly, it assists the boiler surface by supplying to it water upon which part of the work of steam making has already been performed, reducing thereby the proportion of work which must be performed by the boiler in transmitting heat to the water.

The fuel saving to be expected from the installation of economizers may be estimated roughly at the rate of 1 per cent for each 10 deg. F., through which the water is raised in temperature; or, in the average plant, 1 per cent for each 20 deg. F., by which the temperature of the flue gases is reduced. Inasmuch, however, as the determination of the number of degrees that the water will be heated or the gases reduced in temperature by an economizer of given size involves considerable calculation and some knowledge of economizer engineering, it is more convenient to use the chart presented in Fig. 6, which is based upon the actual results secured in some 200 plants where economizers have been installed. Suppose, for instance, that \$3.00 coal is being used, as before, and that it

is decided that the economizer should show a gross saving of 30 cents per square foot per year. If the plant is operated 10 hours per day, 300 days per year, or 3000 hours per year in all, it will be in operation only a little over one-third of the time for which the chart has been made out, namely, 24 hours per day, 365 days per year, or 8760 hours. Therefore to earn 30 cents per square foot for the year as a whole, a square foot of surface must earn at a rate approximately three times as great, or 90 cents, on the basis of the time for which the chart is figured. Finding 90 cents in the \$3.00 coal column, run horizontally until the curve is encountered, from which it is seen that 1.1 sq. ft. of surface should be installed per boiler horsepower developed, for each 110 deg. F. difference between the temperature of the flue gases and the temperature of the water entering the economizer. Supposing as before that the former is 650 deg. F. and the latter 200 deg. F. giving a difference of 450 deg. F., it will be seen that 5 sq. ft. of economizer surface should be installed for each boiler horsepower developed; that is, each 30 lb. of water turned into steam per hour.

### Oxy-Acetylene Welding.

By W. I. REICH.

A review of the oxy-acetylene welding process shows that the business has grown beyond expectations from a few hundred installations in 1908 to over 10,000 blow-pipe equipments at the end of 1911.

The great impetus for this industry was the large improvement in the manufacture of oxygen, which was 5 cents in the year 1907 and is now 1½ cents per cubic foot, compressed in

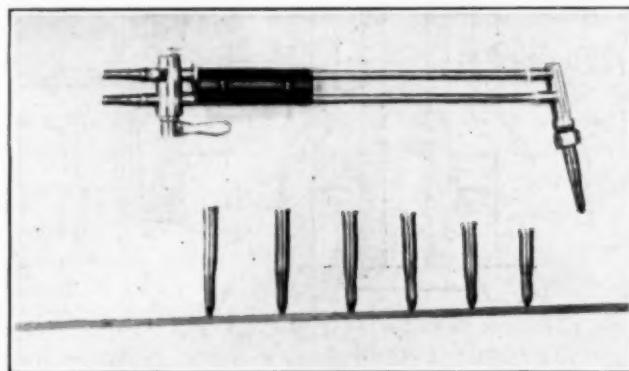


FIG. 1.—BLOW PIPE.

steel cylinders. The dissolved acetylene is still expensive, as there is no competition in this line, and the same applies to the manufacture of carbide.

However, these two "good" trusts are doing something for us for which we have to be thankful, that is, they produce materials of very good quality, far better than in Europe, where competition in this line is very keen. The price of carbide at \$70 per ton is still too high in the writer's opinion and the hope may be expressed that with the extinction of the original Wilson patents this year we will get a cheaper carbide.

### Some of the Uses of the Process.

The industry has spread very nearly to all classes of manufacturing. We find them in the foundry, to repair castings; in the pipe shop, to weld on tees, flanges; in tank factories, for seamless pressure tanks; in shipyards and in railroad shops for manufacturing and general repairing; in the automobile field, for welding cast iron, aluminium, steel and copper parts; in the hospital furniture industry to weld the joints without fittings, and last but not least is the development of the steel cutting business, which was well noticed last year in New York City, when the main streets were widened, and the vault I beams in the sidewalk had to be shortened. The process became so

common that the operators in the street were not annoyed any more by spectators.

#### Development in Blow Pipes.

The writer brought out last year a new "no-backflash" blow pipe, as shown in Fig. 1. Fig. 2 is a section through the head in large scale.

In the sketch we can see both gases conducted separately to the head, the oxygen in the center, the acetylene surrounding it. The acetylene is screened off by a perforated plate *a*, the plurality of orifices in this screen are covered by a check valve *b* which moves freely, its stroke being determined by the nut *n*. The check valve will admit acetylene freely during normal op-

to insure a good mixture. The mixer has a center channel and an annular channel into which part of the mixture is forced through the small opening *r*. From there a plurality of spiral slots allow the gas mixture to feed the center flame, preventing its blowing out. The spiral flames give the molten platinum a rotary motion, which is quite important in the art of platinum melting. With a small blow pipe about 50 ounces can be melted at a cost of 8 cents per ounce. Large blow pipes will melt easily 500 ounces at a much lower cost.

New York City.

#### A Modern Electrotyping Plant.

The top floor of the new seven-story building at the corner of Seventh Avenue and Fifteenth Street, New York City, erected by Messrs. Street & Smith to house their great publishing business, contains one of the most modern and adequate electrotyping plants in the country. Although as to the number of machines not the largest in the city, it is complete as an adjunct to or a part of a great publishing house equipment, comprising the most up-to-date methods and devices to save time, not only in the direct manufacture of the printing plates themselves, but in the different pressrooms which handle these printing plates.

It is an all important factor to the production of printing plates by the electrolyte process to produce plates that "will print and print well," plates which when they are put on the presses need no further preparation but which permit of the almost immediate starting of the presses on their so-called "runs." This fact is particularly important with the last forms (usually the advertisement section), which must be printed before the issue of the publication. To cause a publication to be late on the news stands is "an unpardonable sin" in a publishing house. Consequently in the last rush hours even minutes are valuable.

The layout of this electrotyping plant was all contemplated and arranged before the erection of the building. The location of machines was plotted and every piece of apparatus was provided on plans drawn from the architect's plans of the building, so that when the plant was installed in accordance with these plans, each machine when placed on the floor was in a correct position with relation to the outlet through which the wires for the motors came through the floor, the metal conduits for the electric wires being put under the flooring, part of which is granolithic, when the building was constructed.

In plotting the layout squares of cardboard, in some instances rectangles, were cut to scale, showing the relative positions of both motor and starting box for the respective machine. These bits of pasteboard or miniature machines were all laid on the floor plan and arranged in what seemed to be the most advantageous layout and a tissue tracing made of the arrangement and then other arrangements were tried and checked. Finally what appeared the best grouping and arrangement was selected and adopted, the final plan being drawn and blueprints made for the different artisans who were to contribute to the laying out and installation of the plant.

The principal objects were convenience and the saving of steps to the more skilled and consequently higher priced employees. Most of the carrying of work in process, was planned to be performed by laborers or helpers. The arrangement was such as to have the work advance in progressive steps from one operation with a predetermined regularity around the room, to be completed nearly beside the point from which it started.

Not only was it necessary to provide for the general layout, but it was important to consider the proper care of certain wastes necessary in the electrotyping business. For instance, an iron oxide dust is used in one of the manipulations. This is liable to become extremely troublesome in the ordinary sewage pipes of a building having elbows or other turns and traps, as

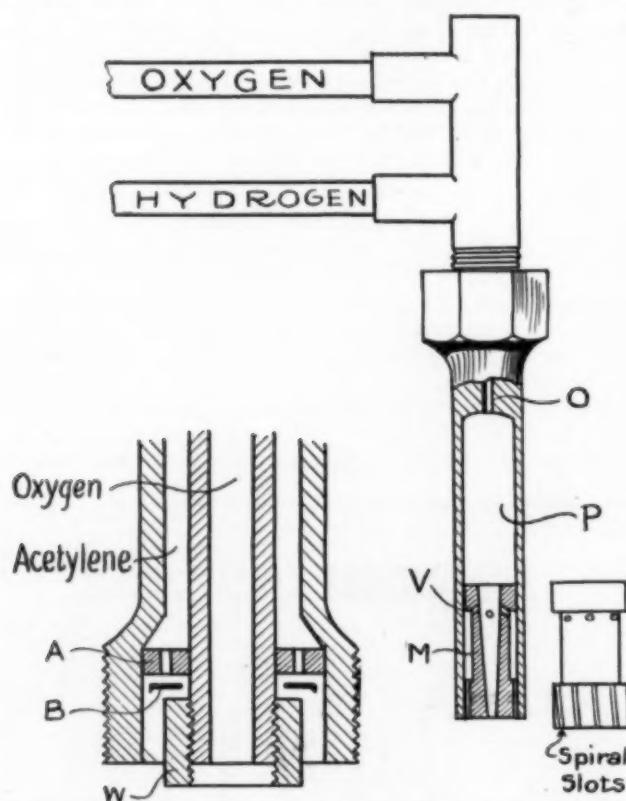


FIG. 2—SECTION THROUGH HEAD OF OXY-ACETYLENE BLOWPIPE.

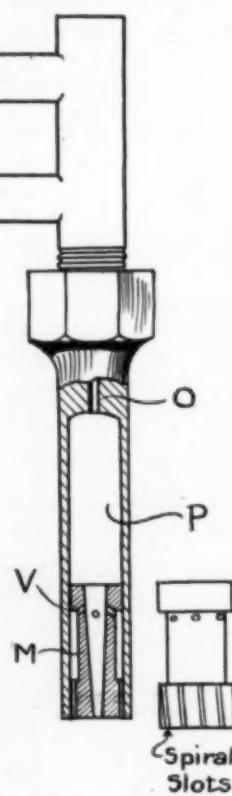


FIG. 3.—OXY-HYDROGEN BLOWPIPE.

eration of the blow pipe, but will close the acetylene channels when any backfire occurs.

The blow pipe is furnished with a number of interchangeable tips for all sizes of welded joints. Each tip represents an individual blow pipe, in as much as length, size of uniting chamber, oxygen inlet, and acetylene orifices change.

This blow pipe does not require a metal bundle filled with pumice stone to check the backflash. Therefore, the bundle is made of insulating material, light in weight and adjustable so that it can be moved nearer to or further away from the head. The control of gases is by means of a double cock, with a small bore for the oxygen and a large one for the acetylene, so that the oxygen can be shut off in turning the handle 15 degrees without contracting the acetylene supply.

#### Platinum Melting.

The writer has installed several platinum melting plants for which the above blow pipe was used. The fuel in this case was changed to hydrogen or illuminating gas.

The fuel gas should be under pressure and controlled by an automatic regulator. The blow pipe tip is made of heavy copper with a mixer as shown in Fig. 3, in which *o*, is a narrow channel and *p* the mixing chamber. At *m* is a mixer head.

The gas mixture passes from the narrow channel *o* to a large mixing chamber *p*, where the speed of the gases is reduced

it will deposit and harden upon the inside walls of a perpendicular pipe unless there is a continuous flow of water through the pipe. Special provision was made for this pipe, which is made of a special acid-proof tile, to obtain a straight, uninterrupted run through six stories to the basement, where it empties into a separating catch basin before entering the main sewer. This basin can be cleaned out as often as desired and the pipe is cleaned out several times each year by drawing up and working down through its entire length a round scraper

The composition is melted and mixed in large steam-heated kettles and poured while in the melted or fluid state over the surface of thin sheet metal backs. After cooling sufficiently a shaving is taken off the surface to insure greater evenness, the surface is dusted over with graphite and the form is pressed into the wax to the desired depth to give contour to the type and sharpness to the cuts.

The surface of the mold is thoroughly polished with graphite to insure perfect electrical conductivity to the surface of the mold, as it later becomes the cathode in an electrolytic operation.

Before the mold is placed in the electrolytic bath it has a very slight coating of copper precipitated over the surface of the wax owing to the chemical transposition which takes place when powdered iron is added to dilute sulfate of copper solution, which has been flowed over the graphited surface of the wax mold and agitated by means of a soft bristle brush. This coating becomes the base of the deposit which begins to build up simultaneously over the entire surface of the mold. Without this preliminary coating, the deposit of metal starts at the connectors at the edges of the molded surface and gradually spreads over the entire surface, which consumes about thirty minutes before the deposit begins to thicken and the extreme edges will be much heavier than the central portions.

After the mold has been thor-

oughly rinsed off or washed out to remove any surplus graphite and powdered iron as well as to break up any oxidation, the mold is hung in the electrolytic bath, composed of a solution of the salts, of whatever metal is to be deposited, dissolved in water slightly acidulated with some acid, usually sulfuric acid. The printing-plate-making industry has only to do with the deposition of copper and nickel alloy, exhibiting properties which lead many to believe that the deposit is nickel-steel. Street & Smith employ copper wholly, as it has been found to withstand all the runs which they give their plates. Some have already given over a million impressions and are good for at least half as many more.

Particular attention is given in this establishment to the deposition of the copper shell, which is the wearing element of the printing plate. Toughness of the texture of the deposited metal is not sacrificed to hardness and the elemental condition of the electrolytic baths are maintained and never permitted to deviate from a fixed standard which insures a deposit of metal which is always the same. The temperature of the baths is kept at the same point both summer and winter, which is also an important factor in this work. The solutions are mechanically circulated in the tubs sufficiently to produce an even deposit at all points of the cathode.

The generating outfit consists of two 20-kw octipolar units built by the Jantz & Leist Company, Cincinnati, Ohio, each direct-connected through a flexible coupling to a 27-hp slow-speed multipolar motor, the armature making 600 revolutions per minute. Each generator is capable of generating 2000 amp at from 1 to 10 volts and maintaining a constant potential on all loads. This is a special feature of these particular machines due to the fact that their field coils are separately excited by the current operating the motor. A field rheostat per-

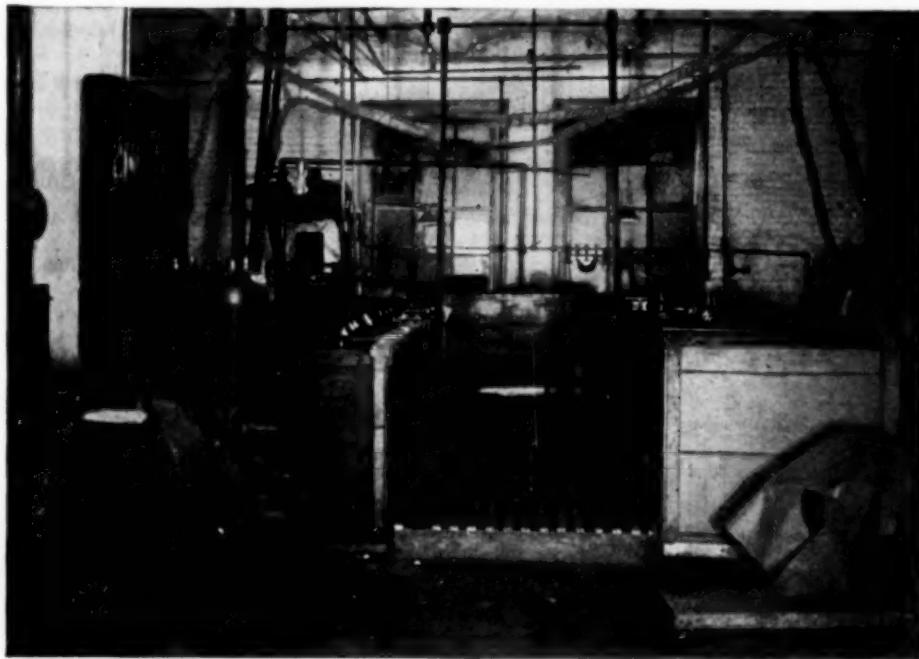


FIG. 1.—TUBS AND PART OF THE PLATING EQUIPMENT. THE ONLY SHAFTING IN THE SHOP OVER THE TANKS OPERATING FOUR CIRCULATING PUMPS IN THE PLATING TANKS.

device similar to the flue cleaners used within the steam boiler.

The process of making printing plates by the electrotype or galvanoplastic art as carried on in this establishment may be briefly described as follows:

The forms composed of reading matter or illustrations, represented by movable types or the so-called "linotype" slugs wherein the individual letters are cast into concrete and movable lines, and metallic plates bearing upon their surfaces the etched intaglio of the illustrative picture or design, are assembled and placed within a steel frame, secured with mechanically-operated wedges called quoins. This is the preliminary composing room operation.

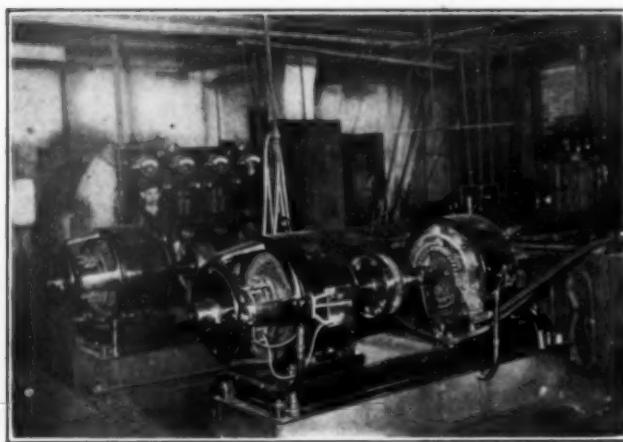
The forms coming to the electrotyping department are washed, dried, placed upon the molding press, where the cleaned surface is lightly dusted over with powdered graphite which lubricates, preventing the form sticking in the wax into which it is pressed, giving a print in bas-relief of the form in the wax, and as a preliminary to the metallic coating which the surface of the wax must receive later, before it will take the deposit of metal in the electrolytic bath.

In taking these impressions in the wax it is necessary at times to develop pressure as high as 4500 lb. to the square inch of form surface pressed into the wax to a depth never greater than  $\frac{1}{8}$  of an in. To produce this pressure hydrostatic presses made of steel are employed. For lower pressures, not over 1000 lb., screw-actuated toggle presses are employed. This plant is equipped with both the hydrostatic and screw-actuated toggle presses.

The wax into which these forms are pressed is composed in the main of ozokerite, a petroleum residue, to which are added numerous gums or resins according to the fancy of the operator.

mits adjustment of the excitation of these coils, so that the voltage of the generator may be fixed as desired upon starting the machine, and thus be maintained throughout the entire time of running, without giving attention to the addition or removal of molds from the baths, since the voltage remains constant from one mold up to the full capacity of the generator.

The electrical and mechanical features of these Jantz & Leist sets deserve special mention. The armatures are of the gramme ring type, which is particularly adapted for the generation of very large currents, since better ventilation can be more easily obtained than with the drum type. The windings of the armature are in the form of copper bars, not wrapped with any insulating covering, each being separated by an open dividing space from its neighbor. There is a ventilating aperture communicating with the central opening within the armature outward, between the bars. When the armature rotates the centrifugal force drives the air out through or between the bars



TWO MOTOR-DRIVEN PLATING GENERATORS SHOWING SWITCH BOARD AND CONNECTIONS TO TUBS.

and cools them. Owing to this fact, these generators are capable of overloads as high as 50 per cent. But as this concern does not believe in the economy or safety of overloads these generators have been built of sufficiently large capacity to do all the work required before they have been taxed to within 75 per cent of their rated capacity, leaving 25 per cent as a factor of safety and an additional 25 per cent as an emergency factor.

The commutator efficiency of these generators has been greatly increased by the adoption of a special arrangement of specially made carbon brushes furnished by the United States Carbon Brush Company. There are on each generator eight sets of four brushes each, three brushes in each set being made with particular consideration for their conductivity while the fourth contains sufficient graphite to provide perfect lubrication to the commutator surface which passes under it. These lubricating brushes are set staggering with relation to the other brushes around the commutator, thus lubricating the entire commutator surface without any form of grease or oil. They have now been in use two years and three months and during that time the commutators have not been touched either with sandpaper or any other substance or device to smooth them, neither have they had or required the application of any lubricant whatever on their surfaces.

Each set, motor and generator, is placed upon an 18-in. I-beam base carefully levelled and grouted in with Atlas cement 3 in. deep, poured inside, giving a perfectly solid, rigid foundation, bringing the machines up high enough to make the oiling and cleaning easy. The armatures are dusted out each day by means of a hose supplied with compressed air and particular attention is given to the brushing, wiping and oiling of these machines each morning before starting up.

Each machine supplies energy for two plating tubs connected in series, through 2½-in. solid copper conductor rods fastened

directly to the terminals of the dynamos. Their circular area is ample to carry 2000 amp without heating.

Some carefully conducted efficiency tests made with one of these sets developed the following facts which are interesting but easily understood from the fact that the generators are generally used below their rated capacity.

With 45.83 sq. ft. of cathode surface exposed in the bath the generator developed 750 amp at 6 volts, while the motor consumed 27 amp at 230 volts (of 8.40 hp). The loss was therefore 27.54 per cent from the terminals of the motor to the terminals of the generator, hence the efficiency was 72.46 per cent in the conversion of electrical energy between motor and generator.

With the same exposure of cathode surface the generator was made to give 1120 amp at 9 volts, when the motor consumed 50 amp at 230 volts (or 15.41 hp) showing a loss of 12.35 per cent or an efficiency of 87.65 per cent for the set.

These figures illustrate the usual fact that as the maximum of the motor is approached there is a gain in the efficiency of conversion. However, it is more economical to work below the rated capacity than to go above it as is shown by the following test, made with a plating set in which the motor had a full-load capacity, 33 1-3 per cent below that of the generator.

The motor was a 7½-hp, 230-volt machine, driving a shunt-wound generator (direct connected) generating 800 amp at 6 volts. The motor on full rated load should draw 28.2 amp. With the same cathode surface as in the above tests, the motor drew 37.5 amp at 230 volts, so that there was an overload of 3.8 hp or 50.76 per cent, causing excessive sparking at the brushes and heating the commutator and armature. The generator gave 750 amp at 6 volts. Hence the loss was 47.84 per cent and the efficiency 52.16 per cent.

After the deposit of metal becomes sufficiently thick it is removed from the wax mold, thoroughly washed to remove all adherent wax, and has a soft metal backing sweated to it by being placed in a shallow pan, having sheets of solder foil laid over the back and melted. Molten backing metal is poured carefully over this melted solder foil, to the desired thickness and the whole is allowed to cool. The result is a soft metal plate with a copper, nickel or other metal face as may be desired or required.

The plates are cut into the required sizes, the surfaces are trued up to the same plane and the backs are machined perfectly parallel with the surface. Many of these plates are "curved" and are fitted to the cylinders of the large printing presses which print thousands of copies every hour.

Messrs. Street and Smith issue thirty-eight dated publications each month ranging from 32 to over 300 pages each, for which is required nearly 5,000,000 square inches of electrotype plate work during the year.

This branch is in charge of Mr. George E. Dunton who has a very wide reputation as an authority on the art of electrotyping, based not only on his contributions to the literature of the subject but to the more than twenty patents taken out by him for methods, devices, and mixtures which relate to improvements in the production of printing plates by the electrotype process.

#### NOTES.

The **American Rolling Mill Co.** of Middletown, Ohio, have issued a nicely illustrated pamphlet entitled "Public Opinion on American Ingots Iron," giving quotations from various authorities on the relation between purity of iron and its resistance to corrosion.

The **Rockwell Furnace Company**, New York, have opened an office in the Engineers Building, Cleveland, Ohio, for the sale of furnaces for heat treatment, annealing, tempering, etc. The office will be in charge of Mr. George B. Norcross, who will have associated with him Mr. Walter F. Johnson, formerly assistant treasurer of the King Bridge Company, Cleveland, Ohio, and Mr. E. W. Saunders, of the Carbon Steel Company,

**Oil Furnace for Heat Treatment of Steel Forgings**—The Rockwell Furnace Company, of New York City, has recently completed for the Heppenstall Forge & Knife Company, of Pittsburgh, Pa., and Bridgeport, Conn., three of their overfired type furnaces for the heat treatment of steel forgings, the largest furnace having a heat chamber 4 ft. wide and 50 ft. long. The fuel used is oil.

**Mr. P. E. Garretson** and associates, who have successfully placed upon the market an ore reducing machine, known as the National Pulverizer, have purchased from the Samson Manufacturing Company all rights, title, interest, good will, etc., for the manufacture of the Samson rock crusher. The company will not confine its business to the mining industry alone, as this crusher is adapted for all kinds of rock breaking, such as rock for concrete, road work, etc., lime, cement, coal and other products where a uniform product is desired. The business will be continued under the name of The Samson Manufacturing Company at 1738 Broadway, Denver, Col.

**Pyrometers**.—We have received from the Brown Instrument Company, of Philadelphia, their new illustrated 56-page catalog on Brown Pyrometers. This is very complete, covering both indicating and recording pyrometers. Section I deals with electric pyrometers and radiation pyrometers, section II with expansion pyrometers, mercurial pyrometers, and other types. While the immense strides in design and applications of pyrometers have chiefly been made in the last few years, it is interesting to note that this company originally commenced to manufacture expansive pyrometers in 1860 or over fifty years ago.

**Optical Projection**.—A recent bulletin, issued by the Technical Bureau of the Bausch & Lomb Optical Company, of Rochester, N. Y., on "A new balopticon for projection of large opaque objects" is unusually interesting as evidence of the rapid strides now being made in the development of optical projection and in general in design of special optical instruments.

**Bolting Cloth**.—"From Mulberry Tree to Mill" is the title of an illustrated pamphlet issued by the old firm of Dufour & Co. and sent to us by their agent, Mr. Paul O. Abbe, 30 Broad St., New York. It describes in an interesting general way the many operations in the manufacture of Dufour bolting cloth, the silk for which is spun from the best white cocoons which are raised. The factory of Dufour & Co. has been since 1833 in Thal, Switzerland.

**Competition in Aluminium Manufacture**.—French and Swiss capital is to be invested in an aluminium plant in North Carolina. L'Aluminium Français which has been organized in Paris with a capital of 15,000,000 francs, will be the parent company. The operating company is to be known as the Southern Aluminium Company and will have a capitalization of \$8,000,000. The company has purchased the partly completed hydro-electric plant of the North Carolina Electric & Power Company, which is a reorganization of the old Whitney Company. There are large deposits of bunxite in the territory. The initial development, partly completed, is of 50,000 horsepower, while other power sites will supply an additional 50,000 horsepower. Dr. Paul Heroult is on the spot to supervise the erection of the works.

**Electric Muffle Furnace for Heat-Treatment of Tool Steels**.—Bulletin No. 10, just issued by the Hoskins Manufacturing Company, of Detroit, Mich., gives a detailed illustrated description of their type FC electric muffle furnace for the heat treatment of tool steel. The furnace is of the resistance type, the heating resistors being two piles of flat carbon plates, which can be compressed more or less by means of a screw, thus permitting an exceedingly easy and exact regulation of current and temperature. Another special feature of the furnace is a draft hole which extends from the top and rear of the furnace chamber to the top of the furnace and by means of which chemical nature of the atmosphere—whether oxidizing or neutral or reducing—can be controlled as desired. The furnace is in successful use in various large steel plants in this country.

**Double-Chamber Furnace for Melting Cyanide Precipitate**.—Bulletin 33 of the Rockwell Furnace Company of New York describes their double-chamber melting furnace for melting copper, brass, bronze, aluminium, ferrosilicon, ferromanganese and other alloys. It is operated by gas or fuel. The essential feature is the provision of two chambers so arranged that they can be used alternately. The exhaust heat from the active or primary chamber passes into the other chamber, thereby simultaneously melting in one chamber and preheating to near the melting point in the other chamber with one burner and no additional cost. An interesting special application of this furnace is the melting of cyanide precipitate, for which purpose it has proven very successful in various cyanide plants.

**"Smokeless Chimneys"** is the title of a twelve-page pamphlet issued by the Furnace Gas Consumer Company, Matteawan, N. Y., describing the furnace gas consumer, which consists of a bank of fireclay tubes installed in the space back of the bridge wall, underneath the boiler. It is claimed that these tubes become white hot or incandescent and that they serve to reheat the distilled gases and air, so that when the two mingle in the space back of the tubes complete combustion takes place before the gases again strike the cold surface of the boiler, and there is perfect combustion without formation of smoke or soot. The device, therefore, really represents a means of heat storage in the furnace, storing heat when the fire is bright and utilizing the same heat for the combustion of the gases distilled when fresh fuel is spread over the incandescent fuel bed. Other advantages claimed for this device are that it makes it possible to secure perfect combustion with a smaller excess of air and that the heat-absorbing capacity of the boiler is increased, due to the increased absorption by radiation, the white-hot tubes radiating into the boiler almost as rapidly as does the incandescent fuel bed, therefore leaving less heat absorption by convection to be performed by the flues.

**High-Vacuum Pump and Pressure Blower**.—The Abbé Engineering Company, 220 Broadway, New York, have put on the market a patented rotary vacuum pump for a high vacuum. This pump, the Abbé Engineering Company claim, will maintain a vacuum to within one-tenth of an inch of the barometer. It runs as quietly as a motor and is simple in construction, having no valves, packing or springs. The internal parts of the pump are automatically oiled, thereby doing away with oil cups. The pump has already found great favor with chemical factories and laboratories and for other purposes where a high vacuum is required. These pumps are built in twelve different sizes, having displacement of from 6 to 1000 cu. ft. of air per minute. The Abbé Engineering Company are also putting a patented rotary pressure blower on the market. This blower requires no air tank as a steady pressure can be pumped up of from 1 to 12 lb. pressure, direct from blower. A relief valve is furnished so that the pressure can be easily regulated. These blowers are fitted with outboard bearings, tight and loose pulleys, and ring oiler bearings.

**Laboratory Apparatus Blue Book**.—The "Blue Book" just issued by the Scientific Material Company, of Pittsburgh, Pa., is certainly one of the most complete and up-to-date catalogs of laboratory apparatus ever published. It contains an enormous amount of valuable information and data regarding almost every piece of apparatus which might be regularly used in chemical, metallurgical, and biological laboratories. The most interesting feature of the book is the large number of new apparatus for producing better results, saving time, saving labor—in short all those apparatus which have been the outcome of the modern tendency of applying scientific management methods in the laboratory. It is a pity that it is impossible to give at this place a list of such apparatus which would show how great the activity of designers has been in recent years along these lines. The book contains 537 pages.

about 10,000 different items, and perhaps 2200 illustrations, and is bound in a light blue flexible cloth. The Scientific Materials Company offer the book free of charge to chief chemists, metallurgists, and professors, and make a charge, which seems quite reasonable, of \$1.50 to others.

### Personal.

**Dr. Victor C. Alderson** has been reelected president of the Colorado School of Mines for the ensuing school year.

**Mr. E. J. Carlyle** has gone to Argentina to take charge of the smelter of the Famatina Corporation at Chilecito.

**Mr. W. Ray Cox**, of Colorado, has been appointed professor of mining and geology in the Pei Yang University, Tientsin, China, and will assume the duties of his position this summer.

**Mr. J. Ross Corbin**, of Philadelphia, has received notification of his appointment as professor of chemistry in the Pei Yang University, Tientsin, China.

**Mr. N. H. Emmons** has resigned as general manager of the Tennessee Copper Company and has opened an office as consulting, mining and metallurgical engineer in the Union Oil Building, Los Angeles, Cal.

**Mr. Oscar Faller** of the Rapid Evaporator Company, Detroit, Mich., recently returned from Munich, Germany, where he has spent the winter. He is at Ludington, Mich., for the purpose of conducting some experiments for his company.

**Dr. Hans Goldschmidt**, of Essen-Ruhr, Germany, with his daughters, Miss Lucy Goldschmidt and Miss Marga Goldschmidt, sailed on June 15 for Europe after a two months' stay in this country in the interest of his celebrated thermit process.

**Mr. Franklin Guiterman**, New York, who is in charge of technical investigations for the American Smelting & Refining Company, visited Denver recently. He resigned as trustee of the Colorado School of Mines on account of his permanent removal from Denver to New York.

**Mr. H. W. Hardinge** left New York on June 1 for Norway to investigate the operation in some of the iron plants of the Northern districts.

**Mr. James A. Jones**, Lansburgh, N. Y., has been appointed Eastern sales manager of the Brighton Firebrick Company, of New Brighton, Pa.

**Mr. C. P. Karr** has been appointed metallurgist to the Standard Chemical Company, Pittsburgh, Pa. The company manufactures uranium and vanadium products.

**Mr. John H. Kennedy** has left the employ of the Punxsutawney Iron Company, Punxsutawney, Pa., and has taken charge of the blast furnace department of the Rogers-Brown Iron Company, operating the Susquehanna furnaces at Buffalo.

**Dr. Chas. F. McKenna**, consulting chemist and chemical engineer, announces the removal of his laboratories from 221 Pearl Street to 50 Church Street, where in the specially designed suite of the top floor of the new extension they have been combined with his offices and enlarged as research and testing laboratories.

**Prof. Robert H. Richards**, of the Massachusetts Institute of Technology, Boston, was married on June 8 to Miss Lillian Jameson, at Jamaica Plain, Mass.

**Messrs. Alfred Sang and G. Rafinesque**, metallurgical engineers, of Paris, France, have transferred their offices to larger quarters at 10 Rue N.-D. de Lovette, Paris.

**Mr. Richard H. Thomas** has returned from Kyshtim, Russia, where he was engaged in improving the efficiency of the electrolytic copper refinery.

**Mr. R. H. Wolff**, well known through his long connection with the steel industry and his great activity in introducing the electric steel refining process in this country, sailed on June 15 for a stay of several months abroad.

### OBITUARY.

**Mr. Seth Clinton Catlin** died at his residence in Bloomfield, N. J., on June 4. Mr. Catlin was the inventor and patentee of the "Nonesuch" electroplating machine and the "Nonesuch" carboy rocker for which Rockhill & Victor, of New York and Chicago, have the sole selling rights. Mr. Catlin was over seventy years of age and had been until a year or two ago actively associated with the electroplating industry for a period of nearly forty years.

**Mr. D. D. Dickey**, general manager of the National Carbon Company, of Cleveland, died on March 8 as the result of an operation for an internal trouble. Mr. Dickey was born at Pittsburgh, Pa., Oct. 9, 1853. In his early life he attended the public schools at Pittsburgh and later the Western University of Pennsylvania, now called the University of Pittsburgh. Mr. Dickey at the time of his death was a patriarch in the carbon manufacturing business of the United States. In 1883 he acquired an interest in the Pittsburgh Carbon Company; a few years later the plant was moved to Jeanette, Pa., and the name changed to Faraday Carbon Company. Mr. Dickey had a controlling interest in this company until the consolidation of several companies into the National Carbon Company of New Jersey in 1899, when he became a director and general manager of the consolidated companies. Mr. Dickey came to Cleveland from Pittsburgh in January, 1899, and has since that date assisted in his quiet, strong way in the advancement of many of the city's interests. He was a member of the Union, Country, Roadside and Rowfant clubs and of the Cleveland Chamber of Commerce and the Chamber of Industry. His death was a great shock to all and everyone who knew him feels a personal loss. Every employee in his company held him in the greatest respect not only as their officer but as their good friend and always ready helper.

### Digest of Electrochemical U. S. Patents.

Prior to 1903.

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Law-Years, National Union Building, Washington, D. C.

#### ORE TREATMENT (Continued).

551,648, Dec. 17, 1895, Louis Pelatan, of Paris, France, and Fabrizio Clerici, of Milan, Italy.

Relates to the extraction of gold and silver from ores containing the same. The ores are pulverized and mixed with a suitable alkaline cyanid solution containing a small quantity of sodium chlorid, to increase its electrical conductivity. The solution of potassium cyanid is kept in circulation either by rotary stirrers or by a suitable pump which draws the liquid off from the top of the solution and injects it at the lower part of the ore above the cathode. A mercury cathode is at the bottom of the cell which may have an amalgam plate resting on its surface. The ore is in contact with the cathode. When stirrers are used, they are connected as anodes. When the solution is circulated by means of a pump, stationary anodes are used. Agitating arms of wood attached to the rotary anodes keep the contents of the vat thoroughly stirred up, while the current is passing through the mixed ore and cyanid. The precious metals will be deposited upon the mercury and may be separated therefrom in the usual manner.

552,960, Jan. 14, 1896, Carl Hoepfner, of Giessen, Germany. Relates to obtaining copper from copper sulfid ores. The sulfur ore is ground and leached by a solution of cupric chlorid containing sodium chlorid or calcium chlorid which reacts with the copper sulfid forming cuprous chlorid and free sulfur. The solution of cuprous chlorid is now separated from the solid residue and any other metals present precipitated. A portion of the solution of cuprous chlorid is now treated with an alkali

or an alkaline-earth in the form of a carbonate or oxid which precipitates cuprous oxid forming an alkaline or alkaline-earth chlorid. Another portion of the cuprous chlorid solution is oxidized to cupric chlorid by any suitable oxidizing agent and used as a leaching agent for fresh ore. If the ore also contains nickel, it is subjected to a preliminary treatment for the extraction of this metal which is then separated from the solvent by electrolysis. The remaining solution is now used to extract the residue from the nickel-free ore.

553,816, Jan. 28, 1896, Louis Pelatan, of Paris, France, and Fabrizio Clerici, of Milan, Italy.

Relates to the extraction of gold from its ores by a cyanid solution or by the chlorination or bromin processes. When the cyanid solution is used, a small quantity of sodium chlorid is added to increase its conductivity, and this solution then mixed with the ore in a suitable vessel, the bottom of which is covered with a mercury cathode. The anode consists of a stirring device which keeps the ore thoroughly agitated. The precious metals are dissolved and collected by a mercury cathode. When the operation is completed, the mercury is collected and the gold recovered in the usual manner.

556,092, March 10, 1896, Oscar Frölich, of Berlin, Germany, Assignor to Siemens & Halske, of same place.

Relates to the extraction of noble metals from their ores by the chlorin process. When other metals are present, the latter are also sometimes extracted, contaminating the solution. States that when a solution containing several metals is subjected to electrolysis and the voltage gradually increased, the most electronegative metal will be deposited first; the next one of the series will then be deposited, and so on. A solution containing 5 grains each of chlorid of gold, copper and iron to a pint, using a lead cathode and carbon anode and a current-density of 12 amperes to 2 square yards of cathode surface, was electrolyzed with a voltage between 1.2 and 1.4 volts. The gold separated completely with mere traces of copper and iron.

563,143, June 30, 1896, James Douglas, of New York, N. Y.

Relates to the extraction of copper particularly from solid cuprous chlorid by means of electrolysis. The cuprous chlorid is obtained by adding a chlorin salt to copper sulfate and precipitating the copper in the form of cuprous chlorid by means of sulfurous acid gas. The cuprous chlorid thus obtained is removed and placed in a vessel and positive and negative electrodes inserted in the mass which may be slightly moistened with acidulated water, if desired. Electric current converts the cuprous chlorid into copper and chlorin, which latter may be collected.

563,144, June 30, 1896, James Douglas, of New York, N. Y.

Refers to the preceding patent in which copper is recovered from cuprous chlorid. In the present patent, the cuprous chlorid and acidulated water are placed upon a cathode within a suitable vessel and an anode immersed in this solution above the cuprous chlorid. The solution is now electrolyzed. If a weak electric current is used, a reguline deposit adheres to the cathode. If a strong current is used, the copper is obtained as a spongy crystalline mass.

566,894, Sept. 1, 1896, Paul Danckwardt, of New York, N. Y., assignor to The Electro-Cyanide Gold and Silver Extracting Company, of same place.

Relates to the extraction of gold and silver from ores or compounds by the action of a solvent and an electric current. The pulverized ore, tailings, etc., are introduced into a rotary vessel, with a suitable cyanid solution. The interior wall of the vessel is connected as a cathode and is amalgamated. Within the vessel, adjacent the cylindrical wall, are a series of shelves which keep the larger particles of the ore from contact with the cathode. The shelves are electrically connected as anodes. Upon rotating the cylindrical vessel, the ore is tumbled from one shelf to another and brought into thorough contact with the cyanid solution. An electric current is continually passed and assists in extracting the gold and deposits it upon the cathode. When completed, the discharged ore and solution go

to a filtering apparatus, and the solution is used over again. The gold is recovered from the amalgamated cathode.

566,986, Sept. 1, 1896, Rudolf Keck, of Denver, Colorado.

Relates to the extraction of precious metals by the cyanid process. After the ore has been treated, the gold-cyanid solution is electrolyzed in an electrolytic cell and the precious metal deposited upon the cathode. In this process, it is preferred to use a cathode of aluminum or its alloys and a lead anode. The precipitated metals may easily be removed from the aluminum cathode and smelted into bullion.

567,503, Sept. 8, 1896, Louis Pelatan, of Paris, France, and Fabrizio Clerici, of Milan, Italy.

Relates to the extraction of gold and silver from their ores by a continuous operation, and refers to patent 528,023. The pulverized ore is mixed with a cyanid solution containing some sodium chlorid and the mass put in an electrolytic cell containing a stirring device preferably connected as anode. The bottom of the cell is covered with mercury connected as cathode. The stirring device constantly agitates the ore and permits larger particles of ore to fall through and be directly amalgamated by the cathode. An electrical current not exceeding three volts is used which is below the point at which sodium chlorid is decomposed.

## BOOK REVIEWS.

**Chemisch-technologisches Rechnen.** Von Prof. Dr. F. Fischer. 12 by 17 cm., 111 pages. Price 3 marks. (Retail price in New York, \$1.00.) Leipzig: Otto Spamer.

**Anwendung physikalisch-chemischer Theorien auf technische Processe und Fabrikationsmethoden.** Von Prof. Dr. Robert Kremann. 15 by 24 cm. 208 pages, 35 illustrations. Price, marks, 9.60; bound, marks, 10.95. (Retail price in New York, bound, \$3.65.) Halle: Wilhelm Knapp.

These two books following on Dr. Haber's splendid "Thermodynamik technischer Gas Reaktionen" demonstrate the ability of German chemists in the important field of industrially using quantitative calculations based on physico-chemical investigations. The first work, however, is the arithmetic of the subject, the second the calcules.

Dr. Fischer of Göttingen, known for his fine work on "Kraftgas," intended his book primarily for students in technical institutions. It contains 196 problems, stated very briefly and almost all accompanied by the solutions given in the briefest possible style. This manner of presentation is very well fitted to help the student to a proper degree and yet to leave him plenty of headwork to accomplish. The use of the "rule of three" throughout strikes us as an anachronism; a man, even a student, who cannot formulate such a process as the primary value multiplied by A over B, without putting down  $B : A = V : X$  — is not very far along in mental arithmetic, and may even be regarded as clumsy in his mental processes. Anyone who studies through this little book in detail will certainly become proficient in chemical arithmetic.

Dr. Kremann of the Polytechnikum in Graz, gives us his lecture course on the application of theoretical data to industrial chemical processes. The plan and its execution are highly interesting and stimulating. Commencing with a chapter on the two laws of thermo-dynamics, he first discusses reaction velocity and catalysis, as exemplified in such processes as sulphuric acid-lead chamber reactions, oxidation and reduction processes, vitrification, de-vitrification, crystallization. The mass-action law and the influence of temperature on chemical equilibrium are illustrated by discussions of the Deacon process, contact sulphuric acid, nitric acid manufacture, causticizing alkalies by alkaline earths, Scheele's caustic soda process. Dissociation tension is considered in connection with the burning of lime, roasting of ores, blast furnace reactions. The phase rule is applied to precipitation and matting processes, iron and carbon alloys, the puddling process. Transformation

reactions are illustrated by the gypsum, Portland cement, and clay industries. More complex chemical theories are concerned in the discussion of dying, vulcanizing rubber, manufacture of soap, the ammonia-soda process.

Intended primarily for students, these two books can be of great assistance to every one handling chemical processes; the first will give him simple basic principles, the second lead into the refinements of the art of industrial chemistry. They both require hard, earnest application, and are both well worth mastering.

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**The Measurement of High Temperatures.** By G. K. Burgess and H. Le Chatelier. Third edition, re-written and enlarged, 14 x 23 cm (5½ x 9 in.), xviii + 510 pages, 178 illustrations. Price, \$4 net. New York: John Wiley & Sons.

Professor Le Chatelier, in a neat preface, protests that the book is much more the work of Mr. Burgess than of himself; we will, therefore, regard the former as having laid the foundation of the work and the latter of having built the superstructure. The book is really monumental, and the technical world may congratulate itself on having such a treatise quite as heartily as it may thank the authors for having written it. Besides the description and discussion of all forms of pyrometers (except the explosion "bomblets" of Wiborgh) there is a long chapter on recording pyrometers, which will particularly interest industrial users. Pyrometry is a meeting point where pure and applied science are co-operating with wonderful success and splendid practical results, and this book has been a powerful factor in bringing the two together.

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**Lehrbuch der Eisen und Stahlgiesserei.** Von B. Osann, Professor an der Bergakademie in Clausthal. 15½ x 24 centimeters, 5 plates and 526 illustrations, 497 pages. Price, \$5 in New York. Leipzig: W. Engelmann.

There was need of a complete, clear, well-illustrated text book on casting iron and steel, and Professor Osann has supplied the want. He proceeds with characteristic German system and thoroughness through thirty-five chapters, starting with the history and classification of iron and steel, discussing melting furnaces most completely, especially the making up of the charges and the chemical additions, then handles shrinkage and blow-holes in a masterly way, details the methods of testing the product, and describes minutely the operation of molding, flasks, sand, casting over a score of special forms, chill casting, malleable castings, trimmings, cleaning, and finally metallographic examination.

To give in a few words a characterization of the work, we will say that Professor Osann's book covers the subject of the iron and steel foundry in much the same style as Professor Stoughton's well-known text-book covers the whole subject of iron and steel, with the obvious corollary, however, that it goes more into working details of furnaces and plant. American practice is well represented, but the strength of the work is its minute description of best European practice. An English translation would be useful to many who cannot (but should be able to) read the German; it would give them a chance to learn how to run a foundry on better principles than most foundries in America illustrate.

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**Industrial Organic Chemistry.** By S. P. Sadtler, Ph.D., LL.D., Past-President of the American Institute of Chemical Engineers. Fourth edition, revised, enlarged, and reset. 6 x 9½ in. (15 x 24 cm.). 601 pages, 122 illustrations. Price, \$5 net. Philadelphia: J. B. Lippincott Company.

Since the appearance of the third edition of this book, eleven years ago, great advances have been made in the organic chemical industries, and some new ones have appeared. Dr. Sadtler has met this situation by a thorough revision. On carefully

inspecting the work we can say that it is nearly everywhere up-to-date, as complete as can be expected within the space limitations of a single volume, and the information given is useful and accurate. The "Analytical Tests and Methods" and "Bibliography and Statistics," given at the end of each chapter, are a particular feature of the work, especially because Dr. Sadtler makes, in the analytical line, his own personal contribution to the subject matter of the book.

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**The Metallurgy of Steel.**—Vol. I, Metallurgy, by F. W. Harbord; Vol. II, Mechanical Treatment, by J. W. Hall. Fourth edition, octavo, pages 551 and 440, illustrations 289 and 282. Price, \$10. London: Charles Griffin & Company.

Everyone familiar with the literature of steel knows this work and its usefulness. It is undoubtedly the most comprehensive book in English on steel.

The revision has been carefully and well done. A complete set of 80 new photo-micrographs of steel sections has been inserted, plans of several new installations are given; the latest developments in basic open-hearth furnaces and their appurtenances are described. The chapter on electric smelting is not as well done as other parts of the book, too much is reported at second hand and without criticism.

Mr. Hall, in Vol. II, has added new sections on low-pressure steam turbines, gas engines and electric driving of mills, making the volume most thorough and complete. The two volumes taken together give a very comfortable feeling of satisfaction when seen on the shelves of a metallurgical library, and the profession owes a debt of gratitude to these two gentlemen for their assiduous and successful labors.

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**Portland Cement.** By Richard K. Meade, M. S. Second edition, 5½ 9 in. (9 x 22½ cm.), 522 pages, 169 illustrations. Price, \$4.50. Easton Pa.: Chemical Publishing Company.

The author has had long experience in the scientific control of the manufacture of cement. His book is carefully written, the information is reliable, and the presentation is free from hackneyed phrases and views. Just about one-half the book describes the manufacture, from quarrying raw material to packing the cement, while the other half is concerned with chemical analysis and physical testing. The book describes American methods and practice, up to date, in a manner which will be useful to almost any class of readers.

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**A Text-Book of Rand Metallurgical Practice.** By R. Stokes, J. E. Thomas, G. O. Smart, W. R. Dowling, H. A. White, E. H. Johnson, W. A. Caldecott, A. McA. Johnston, and C. O. Schmitt. Vol. I. 6 by 9 inches (15 x 22½ cm.), 468 pages, 128 illustrations. Price, \$6.50. London: Charles Griffin & Company; Philadelphia: J. B. Lippincott Company.

The nine authors are all technical men actively engaged in current metallurgical practice on the Rand, and each writes upon the special part of the subject in which he is best qualified. The result is a most valuable book, both practical and scientific, comprehensive and accurate. Mr. Stokes writes of the general conditions on the Rand, geology, labor and economic relations; Mr. Thomas handles sorting and breaking the ore; Mr. Smart, stamp milling; Mr. Dowling, tube milling; Mr. Thomas, treatment of sands; Mr. White, slime treatment; Mr. Johnson, precipitation, clean-up and smelting; Mr. Johnston, assaying and testing plants; Mr. Caldecott, chemistry of the cyanide process. Fifty pages of useful tables were compiled by Messrs. Caldecott and White. Mr. Schmitt will write Volume II on the design and construction of plants and the transportation of material. The writing is in particularly good style and gives a clean, snapshot picture of Rand metallurgical practice of to-day, cleverly designated by Mr. Stokes as "the rich product of twenty years concentration on the bubbles of experience."